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1976 Reassessment of Noise Concerns of Other Nations. Vol. I. Summary and Selected Topics

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VOLUME I

SUMMARY AND SELECTED TOPICS

AUGUST 1976

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16. ABSTRACT

A review of the noise abatement programs of countries around the world (except the U.S.) including laws, regulations, guidelines, criteria, research, governmental organization, plans, etc., with bibliography and contact addresses to facilitate further inquiry. Also includes international organizations involved in noise control. Both environmental and occupational noise are covered. Topics: Community noise, airport, aircraft, surface transportation, construction noise, occupational noise, noise from factories, noise in buildings. A summary finds that compared to a similar 1971 review, the U.S. has "caught up", information has increased geometrically, many nations now compensate citizens for noise from airports or roads, and noise limits in industry are becoming stricter. Vol. II contains country-by-country reviews. (Portions of this document are not fully legible.)

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U.S. Environmental Protection Agency
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UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

November 10, 1976

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8-2 — In Table 8-1 in the next to bottom line, it is erroneously stated that for the U.S. the Proposed limit "For later" is "85 dBA" and "For when" is "5 years". The "85 dBA" and the "5 years" should be deleted.

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FOREWARD

Five years ago the United States Environmental Protection Agency published the 1971 "Assessment of Noise Concerns of Other Nations," describing laws and noise control activities in many countries. The present report updates and revises the old report, with the addition of information on Occupational Noise and Noise Information Centers.

The information was gathered from foreign contacts by letter, by a review of the world literature, and by direct contact with persons at the International Conference of Noise Control Engineering in Washington, D. C. in April 1976.

It is contemplated that this survey report will be periodically revised and updated. Therefore, readers are encouraged to send corrections and new data to:

Noise Control Requirements & Technology Staff
Office of Noise Abatement & Control
U. S. Environmental Protection Agency
Washington, D. C. 20460

The Informatics Inc. team performing the work of compiling this report devoted many long hours to the task. Principle contributors were: C. Modig, Project leader; G. Khouri, G. Cerny, I. Meyer, and J. Stepanchuk. S. Ballon and L. Jones provided much-appreciated help with editing and the French language. Special credit is due to Mrs. Terri Miller and Agnes Furilla, who provided energetic and patient typing and clerical support and to Mrs. Ruth Ness, Technical Director of Information Analysis, who provided extra production resources when they were needed. Credit is due to the EPA task monitor, John Schettino, for providing prompt feedback and guidance at times when they were needed and in the interim, providing the latitude and time for the project to be completed systematically. Finally, the comments of Harvey Nozick are acknowledged for their part in improving the section on Japan.

HOW TO USE THIS REPORT

- Readers interested in an overview of a country, see Chapter 10 (Vol. II).
- Readers interested in an International Organization, see Chapter 2.
- Readers interested in a particular subject, see Chapters 3-8.
- Readers interested in obtaining more detailed information, see Chapter 9 and the lists of addresses at the back of each Section of Chapters 2 or 10.

Noise Specialists -- This report has been designed to be of use to the general reader and to the noise specialist as well. However, the noise specialist will find that it has frequently not been possible to present all of the details in which he is interested. It has not been considered desirable to do so both in the interest of space, and because such details are likely to become out of date rapidly. Therefore we hope that the Specialist will use the report as a means of undiscovering developments or programs related to his particular interest, and will contact the referenced authorities directly to get more information.

1. SUMMARY

General Impressions

Let us look at some of the main conclusions of the 1971 Assessment of Noise Concerns of Other Nations.

- In noise control activities the U.S. was behind other countries of the world, particularly the European countries, Japan and the USSR.
- There was already a considerable volume of world literature on noise, but the literature showed more research than recommendations and more recommendations than regulations.
- A trend toward establishing unified ministries of the environment was underway in many countries, and it was assumed that this would have a positive effect on the development of better noise control.
- The role of international organizations was minimal and in fact was not specifically emphasized in the 1971 Report Summary.

By 1976, the U.S. is no longer "behind" other countries in noise control, although it still has a long way to go.

Whatever degree of noise abatement has been accomplished by 1976, there has been no abatement in the production of literature on noise. In fact, it has more than doubled. A series of important international conferences from 1972 to 1975 has helped increase the folow of information.

By 1976, the newly-formed unified environmental ministries are already several years old, but their initial regulatory achievements have been less than spectacular. It remains to be seen what salutary effects may eventually result. Possibly it takes several years for new ministries to become productive in the regulatory field, and still more time for the impact of the regulations to be felt.

Impressions By Chapter

CHAPTER	
2. International Organizations	International Organizations were not discussed in the 1971 main summary and not emphasized in the report itself. Except for ICAO activity and isolated studies by OECD and WHO, there was little activity. By 1976 the international organizations had become important forums for exchanging technical information. And the EEC (Common Market), in its role as a customs union, has an important influence in developing and harmonizing the new product noise emissions regulations of its member countries.
3. Community Noise	In 1971 the A-weighted decibel had been picked independently in many places as the best metric of environmental noise levels. By 1976, this trend has reached near-consensus, and the L_{eq} is on the verge of becoming the best accepted single-number evaluator of complex time patterns of exposure to environmental noise. The additional social surveys which have been done have largely substantiated earlier findings about human reaction to noise. More noise surveys have been done, but there is not yet enough comparative data published to indicate whether worldwide noise levels are still rising, and whether the size of noise-impacted areas is still

increasing. However, based on the fact that most noise control measures are only beginning to be implemented, and the fact that the number of noise producing mechanisms continues to rise with the world population, we conclude that in general, the impact of noise pollution continues to worsen almost everywhere. In order to establish measurement baselines, most countries are doing more noise surveys, especially in cities and around airports. Denmark is taking a comprehensive noise survey of the entire country.

4. Aircraft Noise

In 1971, aircraft noise had become a major factor limiting the expansion of airport facilities. ICAO had taken action on noise certification limits for new aircraft types but had not acted on retrofitting existing transport aircraft to quiet them. Retrofit was considered by many national ICAO representatives to be too expensive. In 1971, local authorities were attempting to find other approaches that would work around the lack of basically quiet aircraft.

By 1976 some new airport sites have been chosen after great difficulty (Healthrow, Third Paris), while others are still being stalled or enjoined (3rd Tokyo). Programs on the ground to alleviate the effects of the noise are in full swing, including landing taxes, curfews, and quotas on numbers of operations at a airport. Countries like West Germany, Japan, France, and the United Kingdom have started programs for subsidizing the noise abatement treatment of houses in high-noise zones near airports. Their decision to undertake such a relatively expensive measure emphasizes the severity of the problem and the need for better use of other options such as reduction of noise at the source and increased acceptance of flight operational techniques for noise abatement.

Although ICAO continues to work on extension of the noise certification concept to other types of new aircraft, it has avoided an active role in resolving the retrofit question. Only Japan has ordered retrofit kits for some of the transport aircraft in its national airline fleet.

5. Surface Transportation Noise

In 1971 noise from motor vehicles had been identified everywhere as a key culprit, and most countries had some laws dealing with it. By 1976 laws have become stricter and more sophisticated. Road traffic noise is still the number one problem, and still is the area of greatest noise control activity.

Many countries are tending to adopt the same new-vehicle limits as those mandatory in the Common Market (EEC). Both EEC and ECE panels of experts are preparing new reduced noise limits for new vehicles that will go into force in the 1980's. The idea of requiring noise-regulated vehicles to maintain their quiet performance for some length of time after sale (e.g., for the "useful life" of the vehicle) is still an idea for the future. Only Czechoslovakia has such a requirement. There existing vehicles may exceed now vehicle noise levels by 2 dBA.

Computerized prediction of models and noise barrier technology are two technologies that have seen rapid development.

6. Noise Control in Buildings

The problem of noise inside buildings concerns both noise coming from outside and noise generated within the building.

In 1971 isolated measures for dealing with both problems had been initiated, including work on developing better measurement methodologies.

By 1976, work has continued not only on the noise-specific measures, but also on the breader front of increased general standardization and harmonization of building codes in general, both within countries and internationally. Future noise abatement activity will take place increasingly in this context.

One of the main features of the last few years has been increased use of national programs to protect the exterior shell of buildings from traffic and/or aircraft noise.

One innovation of note was seen in France. Exceptionally well built French housing is eligible for the appellation "acoustic comfort level," which may be used in marketing the new units.

7. Noise from Factories and Construction Sites

In 1971 the problem was being approached with a combination of solutions ranging from individual source control to master planning and zoning.

By 1976 there has been no innovation in solutions, although the number of countries having national noise zoning guidelines (including construction sites and industry) had increased.

A major change has been the increase in regulations limiting noise from individual pieces of construction equipment. W. Germany, France, Austria, and Switzerland are among the many countries with such limits. Some countries also are bearing down hard on all existing construction equipment noise. For example, Austrian provinces have such regulations, and in Switzerland a noise permit must be applied for each time it is desired to use an older, more noisy piece of equipment.

West Germany has developed a means of rewarding quieter construction equipment by permitting equipment 5 dBA or more quieter than the legal limits to bear the label, "Superior Construction Machinery."

The ISO Draft Recommendation 1996, a method of assessment of likelihood of community disturbance from industrial noise, progressed to full-fleged Recommendation status.

8. Occupational Noise

Since 1971 it has become increasingly recognized that occupational and environmental noise must be considered together in evaluating total exposure to noise.

In the 1973-74 period an especially large number of countries converted voluntary or "guideline" noise limits to legally binding limits. Most countries in principle require engineering controls to be applied as technically feasible, with hearing protectors as a second line of defence.

However, some countries in practice tend to rely on hearing protectors as a panacea.

In a potentially significant development, W. Germany has adopted the long-standing Soviet practice of requiring much quieter environments for offices than those allowed in factory work areas.

A few countries (Israel, Sweden, W. Germany) have used work place noise signs as a low-cost measure to reduce noise-induced hearing loss. The signs posted at noisy work stations, give the noise levels and remind the worker of the precautions he should be taking.

9. Information

Since 1971 several documentation centers have arisen to help handle the "explosion" in noise literature. However, regularly published statistics on funding, enforcement activities, and measured reduction of noise are as hard to come by as ever. It is to be hoped that the contribution of the international organizations will be to stimulate the creation and distribution of such information.

10. Regulatory Trends

Many of the new environmental agencies which were founded in the early 1970's have taken several years to develop recommendations. Only then is some sort of comprehensive act passed (like the West Germany Act of 1974), which authorizes a series of regulations to be developed and promulgated. Whether the environmental agency is cast in the role of coordinator among ministries (e.g., Switzerland, W. Germany) or is mandated to issue and enforce regulations like the U.S. E.P.A., (e.g., Japan, France), it has the key role of developing and recommending a comprehensive regulatory approach. Where such a basic comprehensive act is missing, as appears to be the case in the U.K., its absence is felt.

In any case, the influence of the environmental agency is typically felt only gradually, because it does not have the unlimited resource to carry out all the mandated actions immediately. For the Common Market Countries, which must consult together, the pace may be further slowed.

Thus it would be a mistake to conclude from the lack of dramatic results over the last four years that important progress has not been made in the fight against noise.

The next logical step everywhere in the world is increased programs of measurement of the effect of the noise control measures already taken, in terms of reduced community noise levels. Increased efforts like that in Austria (where the reduction in noise from construction sites was measured) are to be expected in all countries in the years ahead. Hopefully, more information will also become available on the number of government personnel and costs required to implement the various noise control programs. From the present reporting, only intriguing glimpses have been obtained on this topic -- for example, the fact that on the national level France now has 58 vehicle noise inspection crews.

2. INTERNATIONAL ORGANIZATIONS

2.1 International Civil Aviation Organization (ICAO)

Since the late 1960's, ICAO, a Montreal-based affiliate of the United Nations, whose main purpose is to serve as a forum for matters concerning international civil aviation, has also been active in promoting unified action by all nations in standardizing measurement of aircraft noise levels and impact and setting corresponding noise limits.

2.1.1 Organizational Summary

ICAO interprets its mandate to include being the forum for discussion of the impact of aviation on the environment. At the working level, a committee of specialist advisors (CAN -- Committee on Aircraft Noise) presents recommendations to the ICAO Council for adoption as Recommended Practices, Standards, Procedures for Air Navigation Services, or Guidance material. The Council members are representatives from agencies of the various member governments.

Comments on CAN recommendations are made by member governments and by the ICAO Air Navigation Commission before action is taken. After a recommendation becomes an ICAO Standard, it must still be incorporated in various national legislation before it goes into force for that particular nation. However, the process of incorporation may be complex and ICAO member countries are obliged by treaty to notify ICAO when an ICAO Standard will not be put into effect or a different standard is used. ICAO Recommended Practices are also often incorporated into national legislation.

CAN participants are either members or advisors. One member is nominated by each entity (country or international organization). The entity may also appoint several advisors, who may be either from government or industry. CAN meets approximately every other year. Ad-hoc working groups continue to be active between CAN sessions, working on various agenda items. Sixteen nations and four international organizations participated in the latest (1975).

All noise related ICAO Guidelines, Standards, Recommended Practices, etc. are incorporated into Annex 16 of the "Chicago Convention", which is the treaty instrument binding ICAO members. (The formal title of the Chicago Convention is the "Convention on International Civil Aviation.")

2.1.2 Background (ICAO work in the 1969-71 period)

Measurement, monitoring, abatement, and evaluation of noise were the subjects of a month-long meeting of the ICAO in November and December 1969. The signatories, including all major air nations except the USSR*, began to develop standard procedures for (1) measuring noise for aircraft design; (2) monitoring noise on and near airports; (3) expressing the total noise exposure level produced by a succession of aircraft; and (4) reducing noise through a variety of aircraft operating procedures (2-4).

Aircraft

A procedure for noise certification of aircraft was also passed over the strong objections of the Federal Republic of Germany, Ireland, and the Netherlands, who contended that certain allowances for very heavy aircraft undermined the purpose of noise certification. (2-4) On April 2, 1971, ICAO published standards (2-3) for aircraft noise certification based upon a scheme of three noise measuring points (lateral, flyover, and approach) where the noise levels are dependent upon aircraft weight.

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* The USSR is now a signatory.

The worldwide concern over aircraft noise, particularly that from jets, came at a time when it was estimated that the present generation of aircraft would probably be in use for at least 3 or 10 more years.* Accordingly, attention was directed to retrofitting existing jet engines to make them quieter. The principal impetus came from the United States. ICAO sponsored a retrofit meeting in November 1971, but there was no rapid progress. CAN members asserted that the estimated retrofit cost (then $125,000 to $250,000 per engine or a minimum of $800,000 for a four engine transport) was beyond the capability of most nations.

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* Now, five years later, the estimate is still over 8-10 years from 1975!

Airports

Although accord was reached on a means of expressing the total exposure to aircraft noise suffered by persons on the ground in the vicinity of airports, the discussion about development of criteria and guidance related to the control of land use around airports resulted only in a statement that a minimum of three zones should be established for areas where development is prohibited, restricted, and permitted. There were two basic problems to be overcome in this respect: 1) some countries have recommended that a five-zone, land-use protocol be employed, to give greater flexibility to planners; and 2) there was disagreement over the maximum permissible levels within residential areas.(2-1) The measures that can be imposed by any national state are restricted to some extent by the economic effects of a given action or standard. The ICAO recommendations at the Montreal meeting were adopted as attainable norms; individual states can always adopt more stringent ones. However, some traffic diversion can be anticipated if certain aircraft or certain traffic densities are forbidden at a given airport or within a given nation.

Action on abatement of run-up noise was limited to an exchange of views. The only recommendation emerging from this exchange was that the member states submit results of studies on new or improved methods of reduction.

2.1.3 Recent Work

2.1.3.1 Last Several Years

The following descriptions are derived from the results of CAN's most recent meeting in January-February, 1975 ("CAN/4") (2-2).

V/STOL

The CAN goals are to formulate a noise certification system for all short takeoff or landing (STOL) aircraft. The immediate goal is to draft a Recommended Practice for propellor-driven STOL airplanes (take-off distance less than 600 meters or 2000 feet). As for vertical take-off or landing (VTOL) aircraft, it was considered not yet feasible to set a date for completion of a final specification.

A brief summary of current CAN thinking on STOL was presented. The V/STOL concept would include aircraft capable at flying in patterns similar to helicopters on the one hand or like Conventional Take-Off and Landing (CTOL) aircraft on the other hand. Therefore, any V/STOL requirements must be compatible with planned or existing helicopter and conventional light plane requirements. The current CTOL scheme of three measurement points (flyover, approach and lateral) should be used for STOL also, but the points should be closer in to the runway.

The Working Group for V/STOL was considering a noise level limit in terms of effective perceived noise level (EPNL) in units of EPNdB. Also, to facilitate town planning, measurement data should be provided in terms of the A-weighted level in units of AdB as well as EPNdB. Operating characteristics of the STOL have also been specified and the total package has been adopted as "Guidelines for Noise Certification". After more experience the Guidelines may be ready to be upgraded to an ICAO Standard or Recommended Practice.

A VTOL noise certification scheme is far from completion. Principally affecting helicopters, this scheme still must solve problems such as agreeing on a noise unit that will take low frequency noise and blade slap into account, and finding a flight profile for noise measurement that is meaningful in terms of actual VTOL flight practices.

Propeller Driven Airplanes

There is an existing noise certification scheme, adopted as a Recommended Practice, which was developed at a previous CAN meeting. It only pertains to light aircraft (not exceeding 5,700 kg.) and became effective August 1974. It specifies limits on flyovers in level flight at an altitude of 300 m (1000 ft).

Some nations have already incorporated this Recommended Practice into their national legislation. There are still problems concerning the rigor with which certain operating characteristics are specified during the test:

- A difference in power setting of 25 rpm can cause a difference of up to 1 dB in measured noise.
- Propeller diameter (1 dB per 1.5% variation).
- Temperature variations (1 dB per 10°C).

Nevertheless, the present Recommended Practice is under consideration for upgrading to a Standard.

In regard to heavy propeller-driven airplanes (over 7,500 kg), CAN has decided to recommend the same measuring scheme and noise limits as it would for subsonic turbojet aircraft of the same weight. Data on existing turbine-powered propellor-driven aircraft designed since 1950 indicate that almost all designs could have met these requirements, with two contemporary designs below the requirement by 10-15 EPNdB.

Tightening the Existing Noise Limits for New Subsonic Turbojet Aircraft

The 1975 CAN/4 recommendations for reductions are now under consideration (2-3).

The certification scheme--a continuation of the existing scheme--was adopted after discussion of alternatives that would have made new permissible noise limits dependent on other factors besides aircraft weight, such as on take off distance or aircraft range.

Auxiliary Power Units (APU's)

Based on information submitted at an earlier CAN meeting the Recommended Practices have been proposed by CAN to apply to existing units. The scheme would apply noise limits at cargo and passenger door locations and a specified distance from the aircraft center line. Since these limits might restrict use of some existing APU's, it is desirable that furure APU's, embody substantial noise reductions.

SST's

The CAN position on existing SST's (Concorde & TU-144) is to emphasize that more data on actual noise levels for subsonic flight should be supplied to CAN.

In regard to future SST's, there was a concern that future SST's might not be able to meet more stringent limits proposed for subsonic aircraft, even though they might be designed to meet the limits now existing in Annex 16. Therefore, CAN recommended in 1975 that the presently existing limits for subsonic jet airplanes be used as guidelines for maximum noise from future SST's. Guidelines would be printed in Annex 16 but have less force than Standards or Recommended Practices.

Retrofit

Retrofit as used by CAN refers to existing subsonic jet airplanes still not "noise-certificated," i.e., not meeting the existing limits in Annex 16. The third CAN meeting in 1973 made retrofit recommendations to the ICAO Council which the Council did not accept. Instead, the Council adopted recommendations calling for more information from aircraft manufacturing nations on technical feasibility and cost data, at the same time urging that no state take unilateral action* on retrofit until an international agreement applicable to all ICAO members had been reached through ICAO. In March 1974 the U.S. Federal Aviation Administration proposed just such a retrofit requirement on all planes operating within or into the U.S., whether domestic or foreign flag, to become operative in July 1978.

Information submitted by CAN members at the 1975 meeting showed that most countries considered that (1) retrofit solely by sound absorption materials (SAM) rather then "Rafan" was the only practical potential policy; and that (2) the costs of retrofit were high and the benefits minimal. This position was expressed in one form or another by Italy, the U.K., France, Netherlands, and Sweden. Japan was in the process of retrofitting seven B-797's, 2- B-727's and 16 B-737's but was reserving judgement on DC-8's. The USSR said that "Sam" retrofit would enable several of its current production aircraft types to meet the existing noise limits but that the USSR did not plan to make a decision to implement retrofit until tests were completed by the end of 1975. Others warned that ICAO failure to adopt a policy requiring retrofit would lead to multilateral or bilateral agreements outside of ICAO, unilateral decisions by States and /or a further increase in the growing number of night flight restric restrictions at international airports. IATA said it was not opposed to the concept of retrofit but in fact opposed all existing retrofit proposals.

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* Unilateral action here means the imposition of retrofit requirements by a State on foreign registered aeroplanes operating into its territory.

CAN's recommendations (approved later in 1975 by the ICAO Council) were designed to avoid requiring all states to retrofit all non-certificated aircraft but to urge states to adopt retrofit on a case by case basis, when modifications for a type

> "... are regarded by the State of manufacture to be technically feasible and by the State of Registry to be sufficiently effective and economically reasonable." (Recommendation 1)

Under the second recommendation, States were requested to make such assessments for each type and state their retrofit intentions by January 1976.

Implementation of these recommendations may fail to prevent incompatible requirements from arising between members and thus is likely to satisfy no one.

2.1.3.2 Present and Future

ICAO plans the next meeting of CAN ("CAN/5") for the late fall of 1976 in Montreal. The program and agenda contain further work on all of the areas discussed above, with decisive action perhaps furthest away on thrust reversers. Compatibility of the noise certification schemes already underway will certainly be discussed. The CAN actions on retrofit and future SST's will be influenced by any actions taken by the U.S. in the first part of 1976. ICAO presently finds itself in a position where it is constrained by its members' reluctance to undertake expensive programs in a time of recession on one hand, and fear that unilateral or multilateral actions will increasingly occur outside of the ICAO forum on the other hand, unless progress under ICAO is more rapid.

2.1.4 Useful Data

2.1.4.1 Secretariat address and contacts

ICAO, Committee on Aircraft Noise
1000 Sherbrook Street W.
Montreal, Canada
H3A 2pl

Officers and Secretariat of 1975 CAN meeting (Jan. 27 - Feb. 14, 1975).

Mr. A. A. Maurits was elected Chairman and Mr. M. D. Dunn was elected Vice-Chairman of the meeting.

The Secretary of the meeting was Mr. H. J. Gursahaney, Technical Officer of the Operations/Airworthiness Section, who was assisted by:

Mr. S.O. Fritsch	Chief, Accident Investigation and Prevention Section
Mr. R. Heitmeyer	Chief, Economics Section
Mr. C. Devasenapathy	Technical Officer, Aerodromes, Routes and Ground Aids Section
Mr. G. Finnsson	Economist, Economics Section
Mr. J. C. Rigaud	Technical Officer, Accident Investigation and Prevention Section
Mr. J.S. Shephard	Technical Officer, Operations/ Airworthiness Section

List of CAN Working Groups

WGA.
WGB. VTOL/STOL aircraft
WGC. Propeller driven airplanes
WGD. Subsonic jet airplanes - revision of existing requirements for new designs.

2.1.4.2 Documentation

ICAO discussions are conducted in English, French and Russian. All Working Papers and Reports are issued in English, French and Russian. There is one final report published for each CAN meeting. Views expressed in CAN Reports should be taken as advice of a body of experts to the Council but not as representing the views of ICAO itself. A later supplement to a Report indicates the action taken on the Report by the Council of ICAO.

Other ICAO publications include:

- International Standards and Recommended Practices adopted by the Council in accordance with Articles 54, 37 and 90 of the Convention on International Civil Aviation and are designated, for convenience, as Annexes to the Convention. The uniform application by Contracting States of the specifications contained in the International Standards is recognized as necessary for the safety or regularity of international air navigation while the uniform application of the specifications in the Recommended Practices is regarded as desirable in the interest of safety, regularity or efficiency of international air navigation. In the event of non-compliance with an International Standard, a State has an obligation under Article 38 of the Convention, to notify the Council of any differences.
- Procedures for Air Navigation Services (PANS) are approved by the Council for world-wide application. They contain, for the most part, operating procedures regarded as not yet having attained a sufficient degree of maturity for adoption as International Standards and Recommended Practices.
- There are also technical manuals and ICAO Circulars, prepared by authority of the Secretary General in accordance with the principles and policies approved by the Council.

2.1.4.3 Relations with Other International Organizations

The following other organizations designated people to the CAN IV meeting in the capacity of observers, as listed in Table 2-1.

Acronym		
ISO	Int'l Organization for Standardization	F. Ingerslev
IATA	Int'l Air Transport Association	G.N. Goodman
IFALPA*	Int'l Federation of Airline Pilots Association	R. N. Rockwell

Table 2-1. International Organizations Participating in ICAO Noise Activities.

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* Designated but did not participate in meeting.

2.2 International Organization for Standardization (ISO)*

The ISO is another important international organization doing work on measurement standards related to noise abatement and control. Through its Technical Committee TC-43 and that committee's two sub-committees, ISO International Standards are issued for definition of terms, damage-risk criteria, and measurement of traffic noise, aircraft noise, noise from electrical machines, sound insulation in, housing, etc.

2.2.1 Organizational Summary

The International Organization for Standards (ISO) was founded in 1948. The founders and the member bodies of ISO are the national standards organizations. The ISO Central Secretariat is responsible fo the day-to-day planning and coordination of technical work of ISO. ISO technical work is undertaken by Technical Committees (TC) and their Sub-Committees (SC) and Working Groups (WG). Technical Committees are numbered in sequence in the order in which they are established. The members of Technical Committees are the Member Bodies who have expressed their willingness to participate actively (P-members), or their desire to be kept informed of the progress of work (0-members). Each Member Body has the right to become a member of any Technical Committee or Sub-Committee. Each Technical Committee and Sub-Committee has a Secretariat appointed among the P-Member Bodies of that Committee, and chairmen of Technical Committees may be appointed either for the duration of one meeting by decision of participants at that meeting, or for several years by decision of the ISO Council. A Technical Committee may establish Sub-Committees charged with the study of one or more items included in the Programme of Work of the Technical Committee. The structure of a Sub-Committee is similar to the structure of a Technical Committee. Technical Committees and Sub-Committees may set up Working Groups, comprising a restricted number of individual specialists appointed by the parent Technical Committee or Sub-Committee in the nomination of parent members, to prepare a particular part of the Programme of Work of the parent Committee.

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* Information included in this report about ISO has mainly been taken from the article "Acoustics and International Standardization Current and Future Activities of TC 43" by Dr. Fritz Ingerslev of the Technical University of Denmark published in the Inter Noise 76 Proceedings page 399-404.

Technical Committee 43 on acoustics has been dealing with noise problems since its establishment in the early fifties. Due to the increasing public awareness to environmental problems in the mid-sixties, this committee was reorganized . Two Sub-Committees - SC1 for Noise and SC2 for Building Acoustics were established in 1968.

Most countries of the world, including the USSR, are members of the ISO and as such are entitled to vote for or against accepting the proposal of a technical committee as an official ISO Recommendation.

2.2.2 Background

The International Standards prepared by ISO Technical Committee No. 43 on Acoustics, during the first fifteen years of its existence were of great interest to specialists in acoustics and to the public. These standards are included in annex A of this ISO section. Draft of International Standards are included in annex B of this ISO section.

2.2.3 Present and Future

The object of ISO is to promote the development of standards in the world with a view to facilitating international exchange of goods and services, and to developing mutual cooperation in the spheres of intellectual, scientific, technological and economic activity.

In this respect the scope of the Technical Committee 43 and its two Subcommittees involves standardization in the field of acoustics and noise in all aspects. This scope includes, in particular, methods of measurements of noise and evaluation of its effect on man and environment.

The ISO endeavors to meet this challenge by providing international standards related to noise. At the present time, for instance, TC 43/SC 1 Noise is in the process of preparing and drafting the following series of basic documents for the measurement of noise from various types of machinery.

Work on the following items has reached an advanced stage:

ISO/DP 4870: Acoustics - Recommended methods for the construction and calibration of speech intelligibility intelligibility tests.

ISO/DP 4871: Acoustics - Noise classification and labelling of equipment and machinery.

See also Annex B.

Also, TC43/SC2 is preparing a document on "Laboratory tests on noise emission by appliances and equipment in water supply installations".

2.2.4 Useful Data

2.2.4.1 Secretariat Address; Contact Person

Central Secretariat of
International Organization for Standardization (ISO)
1 rue de Varembe
CH-1211 Geneva 20, Switzerland

Secretariat of ISO/TC 43 and ISO/TC 43/SC 1
Dansk Standardiseringsrad
Aurehojvej 12
DK-2900, Hellerup
Denmark

Secretariat of ISO/TC 43/SC 2
Fachnormenausschuss Materialprufung
Unter den Eichen 87
D-1000 Berlin 45
Germany

2.2.4.2 Information about Documentation Published by the Organization

The following provides information about different ISO documentation and standards.

1. ISO 2204: Guide to the measurement of airborne acoustical noise and evaluation of its effects on man. (1973).

   This International Standard described the general procedures for the measurement of noise and evaluation of its effects on man. It is intended as an introduction to the more specialized intructions contained in acoustical test codes and interpretation procedures published by national and international standardization bodies. This document defines three types of measuring methods, viz.:

   a) The survey method. This method requires the least amount of time and equipment.

   b) The engineering method. In this method, the measurements of sound level or sound pressure are supplemented by measurement of band pressure levels.

   c) The precision method. This method gives as thorough a description of the noise problem as possible.

2. ISO 1999: Assessment of occupational noise exposure for hearing conservation purposes. (1975).

   This International Standard gives a practical relation between occupational noise exposure, expressed in terms of A-weighted sound pressure level in dB, and duration within a normal working week and the percentage of the workers that may be expected to exhibit an increased threshold of hearing amounting to 25 dB or more averaged over the three frequencies 500, 1000, and 2000 Hz solely as a result of noise exposure.

   A revision to the International Standard ISO 1999 was proposed by the United Kingdom on April 14, 1976 at the International Standards Organization meeting at the National Bureau of Standards, Gaithersburg, Md. The proposal, which would change ISO 1999 to conform to the new British standard, will be discussed in a Study Group which will report at the next ISO/TC 43/SC 1-meeting.

3. R 1996: Assessment of noise with respect to community response. (1971).

This ISO Recommendation is intended as a guide to the measurement of the acceptability of noise in communities. It specifies a method for the measurement of noise, the application of corrections to the measured levels (according to duration, spectrum character and peak factor), and a comparison of the corrected levels with a noise criterion which takes account of various environmental factors.

The two last mentioned documents are widely used by national authorities as a basis for establishment of noise criteria or limits.

4. ISO 3740 - 3741 - 3742 - 3743 - 3744 - 3745 - 3746

This series of documents - partly published, partly under preparation - is a particularly significant series which establish the methods to be used to determine the sound power level of a noise source. ISO has decided that sound power level - rather than sound pressure level - should be the primary measure of noise emission from stationary sound sources. All the documents have the principal title: "Determination of sound power level of noise sources".

5. Noise test codes

An important object of TC 43/SC 1 is to develop test codes for measurement of the noise emitted by various noise sources. In order to make it possible to compare the noise emitted by various noise sources this must be done on the basis of some common basic principles. . The task must be accomplished through collaboration with other Technical Committees within ISO or other organizations. A test code includes two main parts, one part describing the technique for carrying out the acoustical measurement, another part describing the conditions of operations of operation of the machine or the equipment. As examples of such documents the following can be mentioned:

R 362: Measurement of noise emitted by vehicles. (1964)

ISO 3095: Measurement of noise emitted by railbound vehicles. (1964)

DIS 3381: Measurement of noise inside railbound vehicles.

DIS 3481: Measurement of airborne noise emitted by pneumatic tools and machines. Engineering method for determination of sound power levels.

6. Building Acoustics

In the fifties, TC 43 elaborated ISO Recommendation R 140: "Field and laboratory measurements of airborne and impact sound transmission". This important document is under revision, and TC 43/SC 2 has prepared a revised Draft International Standard: "Measurement of sound insulation in buildings and of building elements" which has been circulated in 8 parts to the ISO Member Bodies for approval.

ISO/R 717: "Rating of sound insulation for dwellings" is another important document under the jurisdiction of TC 43/SC 2.

ISO 3382: "Measurement of reverberation time in auditoria" has recently been adopted. TC 43/SC 2 is preparing a document on "Laboratory tests on noise emission by appliances and equipment in water supply installations".

7. Aircraft Noise

TC 43/SC 1 has developed the following documents related to aircraft noise:

3891:	Procedure for describing aircraft noise heard on the ground (revision of R 507 and R 1761).
ISO 2249:	Description and measurement of physical properties of sonic booms. (1973).

2.2.4.3 Relations with other International Organizations

The ISO through the Technical Committee 43 has established a close cooperation with many international organizations such as:

International Electrotechnical Commission (IEC)
Economic Commission for Europe, Transport Division (ECE/TRANS)
International Civil Aviation Organization (ICAO)
Commission of the European Communities (CCE)
International Labor Organization (ILO)
World Health Organization (WHO)

and also with other pertinent Technical Committees with ISO.

It is possible through a proper collaboration to ensure that all cooperating organizations use the same test methods and thus avoid technical barriers to trade due to different test methods. An example of such a close collaboration may be illustrative.

In 1973 the Commission of the European Communities made a request to the Secretariat of TC 43 to try to prepare documents which the Communities could use under the principle "reference-to-standard" if that would be possible. As at that time the Communities started a work on the measurement of noise within this field. Civil engineering equipment is material which is imported and exported all over the world and therefore it is in the interest of international trade that different test methods are not made legal in various parts of the world which e.g. could have the effect that the manufacturers have to prepare their equipment in different ways for the different regions of the world. Naturally, it was not the intention that TC 43 should work for the Commission, but rather it should work in the interest of international standardization and in the interest of international trade, and therefore the request from the Commission was discussed at a meeting of Sub-Committee 1 in Paris in the autumn of 1974, and the following resolution was passed:

> "The delegates present, informed of the wish of the Commission of the European Communities to use the principle of strict reference to International Standards whenever possible, so as to avoid creation of technical barriers to trade, have authorized the Secretariat to respond to requests from the Commission in the quickest possible way within ISO procedures."

TC 43 is prepared to establish cooperation along the same lines with other organizations.

ANNEX A

ISO/TC 43 "ACOUSTICS"

Survey of International Standards and ISO Recommendations:

ISO 16 - Acoustics - Standard tuning frequency (Standard musical pitch).

ISO/R 131 - Expression of the physical and subjective magnitudes of sound or noise.

ISO/R 140 - Field and laboratory measurements of airborne and impact sound transmission.

ISO/R 226 - Normal equal-loudness contours for pure tones and normal threshold of hearing under free field listening conditions.

ISO 266 - Acoustics - Preferred frequencies for measurements.

ISO/R 354 - Measurement of absorption coefficients in a reverberation room.

ISO/R 357 - Expression of the power and intensity levels of sound or noise.

ISO/R 362 - Measurement of noise emitted by vehicles.

ISO 389 - Acoustics - Standard reference zero for the calibration of pure-tone audiometers.

ISO 454 - Acoustics - Relation between sound pressure levels of narrow bands of noise in a diffuse field and in a frontally-incident free field for equal loudness.

ISO/R 495 - General requirements for the preparation of test codes for measuring the noise emitted by machines.

ISO/R 507 - Procedure for describing aircraft noise around an airport.

ISO 532 - Acoustics - Method for calculating loudness level.

ISO/R 717 - Rating of sound insulation for dwellings.

ISO/R 1680 - Test code for the measurement of the airborne noise emitted by rotating electrical machinery.

ISO/R 1761 - Monitoring aircraft noise around an airport.

ISO/R 1996 - Acoustics - Assessment of noise with respect to community response.

ISO 1999 - Acoustics - Assessment of occupational noise exposure for hearing conservation purposes.

ISO 2204 - Acoustics - Guide to the measurement of airborne acoustical noise and evaluation of its effects on man.

ISO 2249 - Acoustics - Description and measurement of physical properties of sonic booms.

ISO 2922 - Acoustics - Measurement of noise emitted by vessels on inland waterways and harbours.

ISO 2923 - Acoustics - Measurement of noise on board vessels.

ISO 3095 - Acoustics - Measurement of noise emitted by railbound vehicles.

ISO/TR3352 - Acoustics - Assessment of noise with respect to its effect on the intelligibility of speech.

ISO 3381 - Acoustics - Measurement of noise inside railbound vehicles.

ISO 3382 - Acoustics - Measurement of reverberation time in auditoria.

ISO 3741 - Acoustics - Determination of sound power levels of noise sources - Precision methods for broad-band sources in reverberation rooms.

ISO 3742 - Acoustics - Determination of sound power levels of noise sources - Precision methods for discrete-frequency and narrow-band sources in reverberation rooms.

ANNEX B

ISO/TC 43 "ACOUSTICS"

Survey of Draft International Standards:

		Stage
DRS 140.1 -	Acoustics - Measurement of sound insulation in buildings and of building elements - Part 1: Requirements for laboratories.	36
DRS 140.2 -	Acoustics - Measurement of sound insulation in buildings and of building elements - Part 2: Statement of precision requirements.	36
DRS 140.3 -	Acoustics - Measurement of sound insulation in buildings and of building elements - Part 3: Laboratory measurements of airborne sound insulation of building elements.	36
DRS 140.4 -	Acoustics - Measurement of sound insulation in buildings and of building elements - Part 4: Field measurements of airborne sound insulation between rooms.	36
DRS 140.5 -	Acoustics - Measurement of sound insulation in buildings and of building elements - Part 5: Field measurements of airborne sound insulation of facade elements and facades.	36

		Stage:
DRS 140.6 -	Acoustics - Measurement of sound insulation in buildings and of building elements - Part 6: Laboratory measurements of impact sound insulation of floors.	36
DRS 140.7 -	Acoustics - Measurement of sound insulation in buildings and of building elements - Part 7: Field measurements of impact sound insulation of floors.	36
DRS 140.8 -	Acoustics - Measurement of sound insulation in buildings and of building elements - Part 8: Laboratory measurements of the reduction of transmitted impact noise by floor coverings on a standard floor.	36
DRS 362 -	Acoustics - Measurement of noise emitted by road vehicles.	31
DIS 1683 -	Acoustics - Preferred reference quantities for acoustic levels.	31
DIS 3481 -	Acoustics - Measurement of airborne noise emitted by pneumatic tools and machines - Engineering method for determination of sound power levels.	43
DIS 3740 -	Acoustics - Determination of sound power levels of noise sources - Guidelines for the use of basic standards and for the preparation of noise test codes.	31
DIS 3743 -	Acoustics - Determination of sound power levels of noise sources - Engineering methods for special reverberation test rooms.	41
DIS 3744 -	Acoustics - Determination of sound power levels of noise sources - Engineering methods for free-field conditions over a reflecting plane.	43
DIS 3745 -	Acoustics - Determination of sound power levels of noise sources - Precision methods for anechoic and semi-anechoic rooms.	41
DIS 3746 -	Acoustics - Determination of sound power levels of noise sources - Survey method.	31
DIS 3822.1 -	Acoustics - Laboratory tests on noise emission by appliances and equipment used in water supply installations - Part 1: Method of measurement.	36
DIS 3891 -	Acoustics - Procedure for describing aircraft noise heard on the ground (Revision of ISO/R 507-1966 and ISO/R 1761-1970).	41
DIS 3989 -	Acoustics - Measurement of airborne noise emitted by compressor units including primemovers - Engineering method for determination of sound power levels.	35
DIS 4869 -	Acoustics - Measurement of sound attenuation of hearing protectors - Subjective method.	31

		Stage
DIS 4872	- Acoustics - Measurement of airborne noise emitted by construction equipment intended for outdoor use - Method for checking compliance with noise limits.	31
DIS 5128	- Acoustics - Method of measurement of noise inside motor vehicles.	31
DIS 5129	- Acoustics - Measurement of noise inside aircraft.	31
DIS 5130	- Acoustics - Survey method for the measurement of noise emitted by stationary motor vehicles.	31
DIS 5131	- Acoustics - Noise level measurement at the operator's workplace on agricultural tractors and field machinery.	31
DIS 5132	- Acoustics - Noise from earth moving machinery - Measurement at operator's workplace.	31
DIS 5133	- Acoustics - Determination of airborne noise emitted by earth moving machinery to the surroundings - Survey method.	31
DIS 5136	- Acoustics - In-duct sound power measurement procedure for fans.	31

Advancement stage codes:

31 - DIS being processed for submission to Member Bodies.

35 - DIS submitted to P-members and Member Bodies for combined voting.

36 - DIS submitted to Member Bodies for voting.

41 - DIS the revised text of which will be prepared within a maximum of 3 months.

43 - DIS for which the preparation of the revised text depends on further study of Member Bodies' comments.

2.3 World Health Organization (WHO)

WHO is a United Nations Agency. With respect to noise, WHO is concerned with the effects of noise on people's health and well-being. WHO defines health not only in terms of "absence of disease or infirmity" but includes a general state of physical, mental and social well-being. Therefore, whenever noise interferes with the above criteria, WHO seeks ways to suppress or lower its harmful effects. Noise is consequently studied not only as an occupational hazard but also as a public nuisance.

2.3.1 Organizational Summary

The long-term program of WHO on noise control is intended: to support appropriate institutions in conducting studies on psychosomatic effects of noise; to promote the necessary health guides and tolerance criteria; and to assist in developing training in noise abatement.

2.3.2 Background

A major activity on noise, undertaken by WHO/Geneva was to invite the Director of the Division of Occupational Health, New South Wales Department of Public Health, Sydney, Australia to study noise as an occupational hazard and a public nuisance. The summary of this study was published in the WHO Public Health Papers Series in 1966. (2-7) The WHO Regional Office for Europe prepared its first program on noise control at its 19th session in 1969. A report was issued in its final form in 1970. (2-8)

2.3.3 Recent Work

2.3.3.1 Last Several Years

A special working group was established whose report on noise control program was published in October 1971 and a set of recommendations was issued. (2-9) Another draft document, prepared by the Study Group on Public Health Aspects of Community Noise, was published (in English) under the title "Environmental Health Criteria for Noise", November 1973. (2-10)

2.3.3.2 Present and Future

Headquarters

The workplan of the WHO environmental health criteria developed program indicates that a task force on noise will be convened in the last quarter of 1976 to consider the draft document prepared last year. Publication of a final noise criteria document is planned for the last quarter of 1977. (2-11)

It is important to mention that the U.S. Environmental Protection Agency has been designated as the first WHO Collaborating Center for Environmental Pollution Control. This new Center will advise and assist WHO in planning, developing and implementing projects in different areas one of which is assessment and control of community noise. (2-12)

In the area of traffic noise it has been agreed, under the coordination of the European office, to undertake several studies on urban traffic noise in modern big cities by the use of unified methodology. (2-13)

Copenhagen - Regional Office for Europe

At present the Regional Office for Europe is finalizing a chapter on noise control in building codes. Other activities aiming at assisting member countries in noise control management and particularly those aiming at improving noise control legislation are in progress.

2.3.4.1 Address and Contact Persons (2-14)

Headquarters

World Health Organization (WHO)
Division of Environmental Health
20 Ave. Appia
CH-1211 Geneva 27, Switzerland
Contact: Mr. G. Ozolins
Mr. Henk W. De Koning

Regional Office of Europe

World Health Organization (WHO)
Regional Office for Europe
8, Scherfigsvij
DK - 2100 Copenhagen Ø - Denmark
Contact: Dr. V. Krichagin

2.3.4.2 Information About Documentation Published By The Organization

See References. These documents are not for sale but are distributed through the Regional Office in Copenhagen or the Headquarters in Geneva.

2.3.4.3 Relations With Other International Organizations

WHO officials maintain active liaison with the OECD and ECE Noise Task Forces.

2.4 Economic Commission for Europe (ECE)

ECE is a regional UN organization. At its second session, the Senior Advisors to ECE established a Special Task Force on Noise (April 1974). In October 1974, the following countries agreed on participating in the ECE Task Force: Federal Republic of Germany, Italy, Poland, Sweden, United Kingdom, United States of America, and the Soviet Union. The United States agreed to assume responsibilities of the "lead country" on the project.

2.4.1 Organization and Objectives

The first meeting of the ECE Task Force on noise was held in June 1975 at the Palais des Nations, Geneva, to finalize the noise program and to develop a schedule and calendar of events for implementing the program.

The purpose of the Task Force is to establish a viable means of exchange among the participating countries on various information and data in the areas of noise measurement, economic and cost-benefit studies and any other aspect of better understanding of environmental noise problems and methods for their control (2.4.1).

The major objective of the Task Force noise program is a two year study effort on community noise, defined as follows:

a. Environmental, or outside noise, including that generated by industry will be given the major emphasis. Excluded from consideration is indoor and/or workplace noise.

b. Emphasis will be placed on assembling information on the non-physiological annoyance effects of noise and development of effects criteria. Noise-induced hearing loss and other physiological effects will not be considered.

c. The product of the two-phase program will be a report on the status of current knowledge concerning environmental noise effects and control measures. Each participating country will develop a report based upon the environmental noise-related publications and activities in their country. These reports are scheduled for submission to the lead country (U.S.A.) in March 1976. They will be integrated by the United States into a draft report which will become the basis for the Phase I final report. The target date for producing a final report on the Phase I activities of the program will be early 1977 (2.4.2).

2.4.2 Background

The idea of the Task Force on Noise was developed in January 1974. During the fourth session of the ECE Working Party on Air Pollution Problems held in Geneva from January 7-11, 1974, the proposal was made for the Noise Task Force to be formed and to function under the Senior Advisors to ECE Governments on Environmental Problems.

2.4.3 Scope of Work

Since the main objectives of the Task Force is to identify the current problems and then elaborate on possible measures, the scope of work for the Task Force is divided into two phases. Phase I will concentrate on the identification and collection of information in specified noise related areas from participating nations. Phase II will consist of an analysis of the information obtained from Phase I and will address the goals of the Task Force directly.

2.4.3.1 Last Two Years (74-75)

The proposed (in 1974) scope of work for Phase I is to be completed by the end of 1976. Each participating country shall describe its noise program in the following:

1) Assemble information and/or criteria describing the impact of environmental noise on people, structures, etc.

2) Assemble information and methods for identifying major sources of environmental noise. Included will be the following:

    a) Descriptions of methodologies and prediction models used to identify and classify environmental noise sources.

    b) Classification of major environmental noise sources, characteristics and noise levels into the categories of area and individual noise sources.

3) Description of commercially available noise control technology including costs for application by major sources identified.

4) Description of noise control standards, regulations, laws, land use planning, prevention techniques, source substitution, building codes, etc. Also to be included in this task are descriptions of cost benefit evaluation methods and analysis.

5) Description of measurement instrumentation, methodologies, and monitoring systems for characterizing noise pollution problems.

    a) Standard methods and/or methodologies of noise measurements.

    b) Monitoring systems.

    c) Commercially available measurement equipment.

6) Description of noise research, development, and demonstration activities in areas identified in Tasks 1 through 5.

   a) Resource allocations - 1971 through 1976.
   b) Products expected and timetable.
   c) Performing organizations and country.
   d) Prominent noise specialists and experts.
   e) Scientific and technical publications.

2.4.3.2 Present and Future

Phase II

1) Determine the magnitude and character of the environmental noise pollution problem.

2) Identify the major problem areas in the characterization and/or control of environmental noise.

3) Develop recommended practices and methods for identification and control of environmental noise.

4) Recommend areas of needed research on environmental noise.

The first meeting of the Task Force was held in Geneva in June 1975. The program was finalized and Phase I of the program was initiated. The second and third meetings of the Noise Task Force are scheduled for September 1976. The purposes of the meeting have been tentatively established. They are to develop a detailed Phase II program including recommended plans for an international symposium and to update the calendar of events for implementing the noise program.

The plans for 1976-78 are tentatively set as follows:

3/76	Task Force member reports on status of current knowledge of environmental noise submitted to lead country.
6/76	Lead country circulates first draft of Task Force Report on Phase I for comment.
9/76	Second meeting of ECE Noise Task Force held to finalize Phase II program.
11/76	Lead country finalized Phase I report for distribution.
6/77	Third meeting of ECE Noise Task Force held to review status of Phase II activities and to develop preliminary plan for international symposium.
4/78	International symposium on Environmental Noise held by ECE Noise Task Force.
9/78	Lead country finalizes report on the ECE Noise Task Force Program including transactions from the international symposium.

2.4.4 Useful Data

2.4.4.1 Contact Persons

From November 1, 1975 on Mr. R. M. Marrazzo (EPA/USA) has replaced Mr. E. E. Berkhau (EPA/USA) as Chairman of the Noise Task Force.

Economic Commission for Europe (ECE)
Noise Task Force
Palais des Nations
1211 Geneva 10, Switzerland
Amasa Bishop; Jaek Janczak; Mr. Louznetsov
(Chairman: Rudolph M. Marazzo)

2.4.4.2 Documentation

(2.4.1) UN Economic and Social Council.

Economic Commission for Europe.

Task Force on Noise, Geneva, December 10, 1975.

2.5 Association of French Speaking Acousticians "Groupement Des Acousticiens De Langue Francaise" "GALF"

Founded in 1948, this non-profit association is set up to facilitate the exchange of scientific and technical information among different groups involved in all the disciplines of acoustical sciences. (2-15)

2.5.1 Organizational Summary

This association has a membership of about 800 specialists in the physical and social sciences. The following academic fields are represented:

- Architecture
- Physiology
- Physics
- Biology
- Linguistics
- Music
- Law
- Medicine
- Engineering
- Mechanics
- Electricity
- Construction
- Commerce
- Industry
- Transportation
- Mining
- Government
- Universities

Organization and structure of this association includes special task groups to further its objectives. These special groups as of 1974 were assigned to the following areas:

- Acoustic music
- Physiology and
- Spoken communication
- Architectural acoustics
- Acoustics of aerodynamics
- Electro-acoustics
- Environmental and industrial acoustics.

2.5.2 Background

2.5.3 Recent Work

2.5.3.1 Last Several Years

GALF participated in organizing the "FASE colloquium No. 1: "Acoustics in Telecommunications" and "FASE 75 collequium No. 2: Machinery noise and environment" held in Paris from 29th of September to the 4th of October 1975. (2-15)

2.5.3.2 Present and Future

This association functions mainly in the following areas:

1) Publishing a tri-monthly magazine since 1968: "La Revue d'Acoustique"
2) Arranging for conferences on noise. Thus, between 1970 and 1974 this association convened thirty conferences.
3) Teaching advanced professional courses in coordination with the French Ministry of Education. In 1973, for instance, this association conducted fourteen courses with an enrollment of 850 students.
4) Granting medals and research rewards to persons involved in noise activities.

2.5.4 Useful Data

2.5.4.1 Secretariat's address

Department "Etudes et Techniques d"Acoustique"
C.N.E.T. route de Tregastel - 22301 LANNION
France

Address of the journal of this association:

Revue d'Acoustique
Editions I.P.F., 12, rue des Fossés - Saint Marcel
75005 Paris, France

2.5.4.2 Information About Documentation Published By The Organization

Since 1969, a tri-monthly journal is published by this organization. This journal "La Revue d'Acoustique" deals with current research, activities of various colloquia and specialized associations as well as bibliographies of current literature about acoustics. In additon to this journal GALF has produced the six noise monographs related to the courses of instruction sponsored by this organization.

2.5.4.3 Relations With Other International Organizations

GALF has established contact with acoustical societies in different countries such as Belgium, Italy, Great Britain, Germany, Switzerland, Spain, Poland, United States, and Latin American countries.

International activities of GALF include organizing joint colloquia, exchanging articles from national publications and inviting foreign noise-specialists to present lectures. In this manner also GALF participated in organizing the scientific activities of the European Federation of Acoustical Societies. Close cooperation exists in the same manner with ICA (International Commission on Acoustics).

2.6 Organization for Economic Co-operation and Development (OECD)*

An intergovernmental organization mainly to formulate policies in matters related to economics and development was established in 1960 with its headquarters located in Paris. OECD membership includes the following countries: Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Japan, Luxembourg, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, United Kingdom, United States.

2.6.1 Organizational Summary

The establishment of the Environment Committee by OECD in 1970 marked the first significant step of this organization's involvement in noise problems. This position is reflected in the scope of the task of this committee. One of its tasks is to help member governments in their formulation and harmonization of noise abatement policies. (2-17)

2.6.2 Background

The Organization's Member countries having expresed their increasing concern and the need for a more comprehensive approach to environmental problems, OECD's Council responded with this mandate for the new Environment Committee:

- to investigate the problems of preserving or improving man's environment with particular reference to their economic and trade implications;
- to review and confront actions taken or proposed in Member countries in the field of environment together with their economic and trade implications;

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* This report about OECD has been largely based on the generous contribution of Dr. Ariel Alexander, his memorandum OECD "International Organization", Paris: OECD, 22 April 1976 (Ref. 1).

- to propose solutions for environmental problems that would as far as possible take account of all relevant factors, including cost effectiveness;
- to ensure that the results of environmental investigations can be effectively utilized in the wider framework of the Organization's work on economic policy and social development.

The twenty-four Member countries of OECD produce more than 60 per cent of the world's wealth and enjoy the highest incomes per person of the world. Its Members have the economic and scientific, technological and technical capacity required to master the problems to which production gives rise. OEVD's goal of qualitative grwoth for the Seventies Seventies - economic development coupled with and defined by an improved quality of life is to be achieved through the cooperation of its Members.

In early response to the need of Member countries for mutually acceptable basic concepts for their environmental policies, the Environment Committee (in close consultation with OECD's Industry and Trade Committees) formulated a set of Guiding Principles, which have been adopted by OECD's Council. These comprise:

- The Polluter Pays Principle. As previously mentioned, this is a principle of economic efficiency establishing that the costs resulting from the implementation of anti-pollution measures should be allocated in such a way that rational use of scarce environmental resources is encouraged and distortions in international trade and investment are avoided. It means that these costs should be borne by the polluter, i.e. by the producer in most cases, who may in turn modify his prices accordingly, passing on the costs to the consumer. Thus the cost of anti-pollution measures should be reflected in the cost of goods and services whose production or consumption causes the pollution. Subsidies for such measures should therefore be avoided by public authorities.

- Environmental Standards. While acknowledging differences in environmental policies according to varying national conditions and goals, governments should seek more stringent anti-pollution measures, together with a high degree of international harmonization on both their scope and their timing. Measures to protect the environment should be framed as far as possible so as to avoid the creation of non-tariff barriers to trade. In cases where products which may cause pollution enter into international trade, governments should seek common product standards.

- Other Guiding Principles. In conformity with the provisions of the GATT, these principles aim at avoiding discrimination stemming from environmental considerations against imported products, and to exclude the introduction of compensating import levies, export rebates or other equivalent measures designed to offset the cost effects of differing environment policies. As stated in the Recommendation of OECD's Council: "Effective implementation of the Guiding Principles...will make it unnecessary and undesirable to report to such measures".

OECD's Environment Committee will continue to survey the effective implementation of these Principles, proposing appropriate notification and consultation mechanisms to this end. The practical, as well as the ideal, solution lies in international agreements reached, as in the past, in the forum of the Committee most concerned.

2.6.3 Recent Work

2.6.3.1 Last Several Years

A first report on noise was issued in 1971, entitled "Urban Traffic Noise - Strategy for an Improved Environment". This report contains a technical review of the problem, a detailed description of national legislative practices in the field of noise abatement and eight recommendations to governments which were endorsed by the OECD Council.

In 1971-72, an Ad Hoc Group on Motor Vehicles created by the Environment Committee undertook an extensive study of the economic, social, and environmental implications of abating air pollution and noise caused by motor vehicles. The part of the study dealing with noise included a forecast of urban noise until 1985 and an assessment of the costs of reducing motor vehicle noise emissions at source.

In 1973-1974, the Group on the Urban Environment (a subgroup of the Environment Committee) undertook a broad assessment of existing policies and practices concerning urban noise abatement in OECD countries. Twelve case studies were presented. A synthesis was published in 1975, which included for the first time proposals to adopt economic incentives for improving the efficiency of noise abatement policies, namely noise charges and compensation for noise exposure.

At the same time, the Group on the Urban Environment studied the environmental, urban, and economic implications of airport siting or expansion. The Group concluded that various options were available to governments, and that the creation of huge airports was no longer the best solution. It suggested four alternative strategies to expensive new investments: expanding the capacity of existing airports, improving the efficiency of existing facilities, developing a regional airport network, or even a standstill policy.

The Group also discussed in detail the social cost of aircraft noise expressed in monetary terms and made a comprehensive survey of all technical, administrative and economic instruments which are or could be made available for abating aircraft noise exposure.

The results of the Group's study are contained in an OECD publication issued in 1975 entitled "Airports and the Environment".

In 1974, the Ministers of the Environment of OECD member countries met in Paris for the first time. At the meeting, the OECD Council adopted ten recommendations among which a very important one concerning noise abatement. The text of this recommendation is as follows:

1. That member governments strengthen their noise prevention and abatement efforts through advance planning and through the application of the best available technology, taking into account the cost of implementation.

2. That these efforts include the following elements:

    a) The promulgation of noise emission standards for products which are major sources of noise, and in particular, transportation equipment, construction equipment, and internal combustion engines of all kinds.

    b) The requirement to consider the impact of noise and the desirability of reducing existing noise levels and of avoiding the creation of new noise conditions in the planning, design, approval, construction and operation of all major facilities including housing, highways, public transportation systems, airports, industrial developments, etc.

    c) Adequate education programs and information campaigns designed to make the public more aware of the need to behave in such a manner as to avoid producing unnecessary noise.

2.6.3.2 Present and Future

As a result of this recommendation, a two-year Ad Hoc Group on Noise Abatement Policies was set up at the end of 1975. The mandate of this new group is as follows:

1. On the basis of available evidence regarding the impact of noise on populations, the Ad Hoc Group shall undertake a systematic study of instruments and policies for preventing and abating noise with particular reference to the instructions of the Council Recommendation on Noise Prevention and Abatement. Taking into account the administrative structure of countries, such a study shall in particular concentrate on an analysis of the various instruments, their respective advantages and drawbacks, possible useful combinations, an evaluation of the cost and effectiveness of the different alternatives, as well as the conditions for implementing them in the framework of policies for improving the environment.'
   This study shall be based both on case studies and a systematic analysis of possible strategies, and it shall attempt to identify the essential components of an integrated and effective policy for noise prevention and abatement, including those which can be implemented at low cost.

2. The Ad Hoc Group shall identify priorities and essential steps for gradually strengthening the emission standards applicable to the principal noise sources, taking into consideration technical and economic constraints.

3. In order to avoid non-tariff barriers to trade, as well as trans-frontier pollution problems associated with noise, and to reinforce international cooperation, the Ad Hoc Group shall, in consultation with appropriate international organizations:

i) establish the basis for harmonizing standards applicable to products which are sources of noise disturbance, in particular those which form a significant part of international trade;

ii) establish the basis for harmonizing technical and economic criteria necessary to introduce noise control incentives - such as economic instruments and noise labelling of products;

iii) study various methods and indices for noise measurements.

4. In carrying out this mandate, the Ad Hoc Group will focus its attention on major noise problems such as transportation and construction of noise.

5. The Ad Hoc Group shall develop a procedure in order to report to the Environment Committee on the action taken by member governments pursuant to the Council Recommendation on Noise Prevention and Abatement.

6. If necessary, the Ad Hoc Group shall present proposals for international cooperation with regard to specific problems likely to necessitate concerted policy and action.

7. The Ad Hoc Group shall submit its conclusions to the Environment Committee within a maximum period of two years.

This Ad Hoc Group, chaired by Mr. J. Schettino (U.S. Environmental Protection Agency), decided to carry out its work in three separate panels: panel 1 on decision criteria, panel 2 on economic instruments and land use, panel 3 on direct regulations and low-cost improvements of the ambient noise levels. Fifteen countries and three international organizations are participating in this program, the results of which should be completed by the end of 1977.

2.6.4 Useful Data

2.6.4.1 Secretariat Address; Contact Persons

- Dr. Ariel Alexandre
- Dr. Jean-Philippe Barde
- Mme Francoise Feypell

OECD Environment Directorate
2, rue Andre-Pascal
75016 Paris, France

This international organization maintains a branch office in the United States located at the following address:

OECD
1750 Pennsylvania Avenue, N.W.
Suite 1207
Washington, D.C. 20006

2.6.4.2 Information about Documentation Published by the Organization.

OECD produced the following reports, documents and publications:

- "Urban Traffic Noise", publication, 1971.
- "Airports and the Environment", publication, 1975.
- "Environmental Implications of Options in Urban Mobility", report, 1973.
- "Social Cost of Noise", document, 1975.
- "Strategies for Urban Noise Abatement", report, 1975.
- "Evaluation of Aircraft Noise Annoyance", document, 1975.
- "Tentative Assessment of the Number of People Exposed to varying Noise Levels in Seven OECD Countries", document, 1975.
- "Charging for Noise", document, 1976.

- "Noise Reduction and Energy SavingPolicies", document, 1976.
- "Decision Criteria for Noise Abatement Policies", document, 1976.

2.6.4.3 Relationship With Other International Organizations.

Relationships are established with the European Community (Brussels), with the UN Economic Commission for Europe (Geneva), with WHO, with ICAO, with IATA, with the Council of Europe, with UNEP. All these organizations send observers to the meetings of the OECD Ad Hoc Group on noise. (2-18)

2.7 International Labour Organization (ILO)

The ILO, a United Nations organization, deals with the general problems of labour and of the working conditions and environment in particular. It aims at promoting improvements with regard to protecting the worker against physical injuries, atmospheric pollutants, noise and vibration, etc. and to working out appropriate standards. (2-19)

2.7.1 Organizational Summary

At the 191st (November 1973) session of the governing body, the employers' group and workers' group agreed that the agenda of the 61st (1976) session of the conference should include an item concerning the "working environment: (i) atmospheric pollution; and (ii) noise and vibration". At its 193rd (May-June 1974) session, the governing body placed the item concerning working environment on the agenda of the 61st session of the conference; it subsequently confirmed, at its 194th (November 1974) session,that discussion of the item would be confined to the two aspects referred to above, namely: (a) atmospheric pollution, and (b) noise and vibration.

The governing body of the International Labour Office (of the International Labour Organization) decides on agendas and arranges meetings of experts on particular subjects. As far as noise and vibrations are concerned, the first meeting of experts took place in December 1974.

2.7.2 Background

The protection of workers against hazards caused by exposure to harmful factors in the working environment has been the subject of numerous studies and publications by the office, which may be said to have been dealing with this question, in different forms, since its foundation. The subject has also been raised on many occasions by various ILO industrial committees.

Several ILO Conventions and Recommendations contain general provisions concerning Noise and Vibration, such as Convention and Recommendation No. 120 (1964) concerning hygiene in commerce and offices and Recommendation No. 97 concerning the protection of health of workers in place of employment.

More specific provisions on noise are contained in the ILO Code of Practice on Safety and Health in Building and Civil Engineering Work, the Code of Practice on Safety and Health in Shipbuilding and Ship Repairing and the Code of Practice on Safe Construction and Use of Tractors.

2.7.3 Recent Work

At the meeting of experts on Noise and Vibration which took place on 2-10 December 1974 in Turin and which was attended by representatives of eleven countries (plus official delegates of the ILO), it was agreed that noise and vibration in the working environment constituted a serious human, social, and economic problem.

The experts emphasized the need for noise assessment and for exposure standards following the health criteria of WHO and the international standards issued by the ISO (R-1999 and others) and the IEC.

The experts considered it appropriate to establish detailed recommendations in a code of practice including noise limit levels. This code should not be compulsory, but should provide guidance on noise and vibration control. They stated that for prevention purposes, correction information and training are of prime importance.

2.7.3.1 Last Several Years

The International Occupational Safety and Health Information Center (CIS) systematically collects and analyzes scientific and technical literature from all over the world and the results of this work have been made available to users in the form of index cards and data sheets (including an information sheet on noise in industry). From 1974 on, the CIS issues a single computer-produced abstract bulletin - CIS Abstracts - where literature relating to noise and vibration is selectively abstracted.

The International Labour Review has articles concerning noise and vibration: "Protecting Workers Against Noise and Vibration" (Vol. 105, No. 2, February 1972; and "Occupational Noise and Vibration Protection in the Federal Republic of Germany" (Vol. 105, No. 2, May 1972).

Information on noise and vibration is contained in several ILO publications relating to occupational safety and health, especially: (i) the ILO Encyclopaedia on Occupational Health and Safety; (ii) various publications of the Occupational Safety and Health Series, such as: "Ergonomics in Machine Design" (OSH No. 14); and "Ergonomics and Physical Environmental Factors" (OSH No. 21).

2.7.3.2 Present and Future

The committee on Working Environment of the International Labour Conference (1976, 61st session) had a first discussion on a proposed international convention and supplementary recommendation on the working environment: air pollution, noise and vibration. Reports VI(1) and VI(2) to the 61st session of the ILC contain information on law and practices concerning the prevention of air pollution, noise and vibration.

The ILO Code of Practice on the Protection of Workers Against Noise and Vibration will be published by the end of 1976 as well as another publication in the Occupational Safety and Health Series, which will contain the report and the working papers of the meeting of experts on Noise and Vibration (Turin, 2-10 December 1974).

2.7.4.1 Addresses and Contact Persons

International Labour Organization (ILO)
CH 1211 Geneva 22, Switzerland
Mr. E. Hellen, Chief, Occupational Safety and
Health Branch, Working Conditions and Environment
Department.

2.7.4.2 Documentation

ILO "Working Environment", Report VI for the International Labour Conference, 61st Session, 1976.

ILO "Report on the Meeting of Experts on Noise and Vibration in the Working Environment", at Turin, 10 December 1974, 21 pages.

2.8. The European Community "Common Market" "EEC"

The European Community is an association of nine West European countries working together to improve their peoples' living and working conditions by eliminating as many national barriers as possible The founding members were Belgium, France, Germany, Italy, Luxemberg, and the Netherlands. The United Kingdom, Ireland, and Denmark became members on January 1, 1973. (2-20)

2.8.1. Organizational Summary

The role that the EEC is playing in the problem of reducing and suppressing certain categories of noise can best be understood by brie briefly studying certain provisions of the Treaty of Rome . Article 100 of this treaty states that the Council, acting by means of an unanimous vote on a proposal of the Commission, shall issue directives for the approximation of such legislative and administrative provisions of the member states as have a directive incidence on the establishment on functioning of the Common Market. (2-21) Continuing further in this vein, Article 189 states that directives shall bind any member state to which they are addressed, as to the result to be achieved, while leaving to domestic agencies a competence as to form and means. It is in this legal framework that preparation of certain noise-related directives has been started. (2-22)

2.8.2 Background

2.8.3 Recent Work

2.8.3.1 Last Several Years

In the course of the last few years the Commission proposed a series of directives concerning noise nuisances. Only the directive of February 6, 1970 relating to motor vehicles, published in the Official Journal L-42 (2-23-1970), has been approved by the Council. This directive applies to all motor vehicles intended for use on the road, having at least four wheels, with the exception of agricultural tractors and machinery and civil engineering equipment. This directive, however, is presently under revision. (2-23)

2.8.3.2 Present and Future

The EEC is in the process of determining environmental noise criteria as required by the Community's environment program approved by the Council on November 22, 1973. The objective to be achieved in this regard is determing at what levels of noise various psychological and physiological effects become apparent. The principal concern is with such areas as interference with sleep, speech interference and annoyance.

On the basis of this program, various activities have been undertaken in the following areas: (2-24)

- determination of noise nuisance criteria;
- action on sources;
- research into noise nuisance.

1. Determination of Noise Nuisance Criteria

A resolution is being drafted, the aim of which is to determine the relationship between the exposure of a target to a noise nuisance and the risk and extent of the resulting adverse effect.

2. Action On Sources

Directives presented to the Council.

a) Driver perceived noise level of agricultural tractors. The proposal is for a limit of 90 dB(A) measured by the OECD method.

b) Revision of Directive 70/157/EEC of February 6, 1970 on the noise emitted by motor vehicles. The proposal calls for a reduction of 2 to 4 dP(A), depending on the vehicle category, on the levels laid down in the Directive of February 6, 1970. The measurement remains the same.

c) Civil engineering equipment
Method for the measurement of noise emitted by civil engineering equipment. The aim of the method is to classify such equipment according to their sound power and directivity under typical working conditions and on an acoustically defined site.

d) Jackhammers
This Directive lays down sound power emission levels. It also contains the method of measurement which specifies where and how the jackhammer is to be set up and used as well as the method for calculating the sound power level.

e) Tower cranes and power generators
The main source of noise on building sites are from tower cranes and power generators. The Commission has presented a proposal to the Council for a two-stage reduction in permissible sound emission levels. The levels proposed for the first stage (ending on June 30, 1980) reflect the best existing technology. (2-29) Those proposed for the final stage are

on laboratory trials and hence call for considerable progress in this area. If the European Commission's proposal is adopted, noise from building site equipment will have to be kept within the following limits contained in table (2-2).

Table 2-2. Permissible Sound Emission Level
(Acoustic power in dBA/referred to 1pW)

	up to 30 June 1980	as from 1 July 1980
Tower cranes	108	103
Current generators for welding:		
200 A or less	107	107
more than 200 A	103	98
Current generators for power supply:		
8 kW or less	105	95
8 kW to 60 kW	103	98
60 kW to 240 kW	105	100
more than 240 kW	107	101

f) Motorcycles
Noise emission limits are presently being proposed to the Council based on measurement methods. A directive has been drafted to fix sound emission levels. A method of measurement based on engine speed lays down the motorcycle's operating conditions during the test. Measurements are carried out under static conditions.

g) Measurement of airborne noises emitted in open area upon a reflective area.
A general directive specifying in particular the method for measurement of airborne noises emitted in open area upon a reflective area, has been proposed.

2. Directives being drafted by the Commission

a) Four-wheeled vehicles
A panel of experts has been given the task of devising a method of measuring the noise emitted by motor vehicles as a function of the nuisance caused. The panel has not progressed sufficiently for any conclusions to be drawn. Several member states are at present studying this problem.

b) Domestic appliances
The Commission hopes that it will soon be in a position to draw up, with the help of national experts, outline criteria for the measurement of noise from these appliances with the aim of producing a test code.

c) Labelling
This is planned for various equipment, especially jackhammers and pneumatic drills. The level shown on the label will be the one guaranteed by the manufacturer.

3. Research

Preparations are in hand for an epidemiological survey of the effects of noise on sleep.

2.8.6 Useful Data

2.8.6.1 Addresses of Contact Persons

Commission Des Communautes Europeenes Service
de l'environnement et de protection des consommateurs
Rue de la loi 200, B-1040, Brussels, Belgium.
Contact: Dr. M. Carpentier (Director)

2.8.4.2 Information About Documentation Published by the Organization

1) Reference (2-16). This report was produced in response to a recommendation made by the first meeting of national experts on noise organized within the framework of the Commission of the European Communities at Luxembourg November 28-30, 1973. At that meeting a group of rapporteurs were requested to prepare a joint report on the most significant effects of noise on man. Con Consequently, the group met in Brussels and agreed to undertake the production of this report. This report stands as a scientific background and support to document number V/F/2949/74

2) Reference (2-26) was prepared by the Secretariat in 1974.

2.8.4.3 Relations with International Organizations

In principle the Common Market has agreed that it is desirable to incorporate ISO measurement methods in EEC directives involving noise. In practice the EEC noise measurement committees and ISO committees continue to have their differences in recommendations concerning noise measurement methodology.

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2-12 Memo. E. A. Cottsworth, U.S. Environmental Protection Agency Office of Intl. Activities, to J. Schettino and R. Marrazzo, EPA/ONAC, February 26, 1976.

2-13 Personal communication. World Health Organisation, Regional Office for Europe, Copenhagen, to Informatics Inc., June. 3, 1976.

2-14 Personal communication. World Health Organisation, Div. of Environmental Health, Geneva, to Informatics Inc., June 3, 1976.

2-15 Personal communication. Groupement des Acousticiens de Langue Francaise (GALF), Department Etudes et Techniques d'Acoustique, CNET, to Informatics Inc., June 9, 1976.

2-16 (Reference 2-16 is placed at the end of the Reference List.)

2-17 Alexandre, A. International organizations: unpublished memorandum. Paris, OECD, April 22, 1976.

2-18 Personal communication. OECD, Administrator, to Informatics Inc., May 24, 1976.

2-19 Personal communication. International Labour Office (ILO), Occupational Safety and Health Branch, Working Conditions and Environment Department, to Informatics Inc., July 21, 1976.

2-20 Manhattan Publishing Company. Questions and answers about the European community. Washington, European Community Information Service, 1973. p. 1.

2-21 Hay, B. International legislation on external industrial noise. Applied Acoustics, 8: 133-140, 1975.

2-22 Noel, E. How the European community's institutions work. London, Commission of European Communities, April 1973. 12 p.

2-23 Personal communication. Commission of European Communities Director of Service de l'Environnement et de la Protection des Consommateurs, to Informatics Inc., January 30, 1976.

2-24 Commission of European Communities. Activities of the Commission of the European Communities concerning noise nuisance. ENV/338/75-E. 1975.

2-25 Commission of European Communities. Europe day by day. Euroforum, 4/76: 5, January 27, 1976.

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3. COMMUNITY NOISE

3.1 What Is Community Noise?

The environmental noise problem is a complex one because in any setting, many different sources of noise are interacting. For example, a family in its living room may be exposed to its own noise, noise from the next apartment, and many external sources: road traffic, aircraft overflight, the railroad yard, the air conditioner on the next building, and so forth. It is the sum of all of these external sources that we call community noise. Community noise is the noise in our outside environment, wherever that may be, and of course, the problem of this noise is usually worse in urban areas where sources are more densely packed. Many countries have detailed programs for dealing with the various external sources, and we cover these activities source by source in the chapters that follow. In this chapter we look at programs that tie noise control of all of the sources into an integrated program. This is usually done at the local level. OECD experts believe it is done best at that level. (3-1, p 30) Historically such action has been initiated at the community level, usually in highly urbanized areas. Most of the foreign communities began their campaigns in the late fifties or early sixties. However, although we focus on situations on the community level, there has been a growing trend to recognize that actions at the national level are essential inputs to local success, and there is a trend for national governments, even in federally organized countries like the U.S., Switzerland, and Australia, to accept more noise control responsibility.

In general, limitations on new products and standard road designs are best done nationally or even internationally (3-1, p. 10) But each locality has its own unique noise features and its own wishes about how much effort it thinks noise control is worth. Specific programs for community noise can proceed at both the national and local levels (Table 3-1), in addition to national new product limits and the like.

National	Local
National surveys of problem.	A noise survey.
National criteria newly developed.	Integrated local plan development
National model ordinances for local use.	Regulations.
Nationally developed standard community noise survey methods.	Organizations and funding.
	Monitoring of results.

Table 3-1. Division of Noise Control Activities between Government Levels. (Examples)

3.2 Decision Criteria

In this section, the various factors affecting decisions on community noise regulations are discussed. These include: 1.) general health cause and effect criteria; 2.) survey results showing degree of the local problem; and 3.) noise standards, which are authoritative published guidelines on noise limits which may be either recommendations or mandatory.

Noise Indices

Implicit in any statement of noise criteria or standards is an assumption concerning the proper noise metric or unit of measurement.

For an additional community noise measurement, excluding the measurement of aircraft noise, use of the A-weighted decibel has become standard in most countries, although some of Japan's regulations still use the phon*.

For telescoping a time series of noise level fluctuations data into a single meaningful indicator for the period, the L_{eq} ** (equivalent continuous noise level) incorporates the A-weighted decibel and is at present the best candidate for a standard unit, although the L_{np} ("noise pollution level", developed in the United Kingdom is an alternative. (3-1, p 7) At present there are still other units being used for special situations or in various countries (PNdB, NNI, TNI, CNR, L_{exp}, AI) (3-4). Although it is often possible to convert one unit to another, such comparisons are sometimes difficult. Therefore, it has been suggested that from now on, noise measurements be taken everywhere in L_{eq} as well as whatever other metrics are prescribed. (3-1, p 24) The following graphics have been included in a report issued by the Commission of the European Communities to indicate the extent of the community reaction to noise.

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* Japanese Phon A is usually comparable with dBA for most environmental noise.

** The equivalent noise level, L_{eq}, (also called the average sound level) is the level of a constant sound which, in a given situation and time period, has the same sound energy as does the square A-weighted sound pressure, over a time period that must be stated.

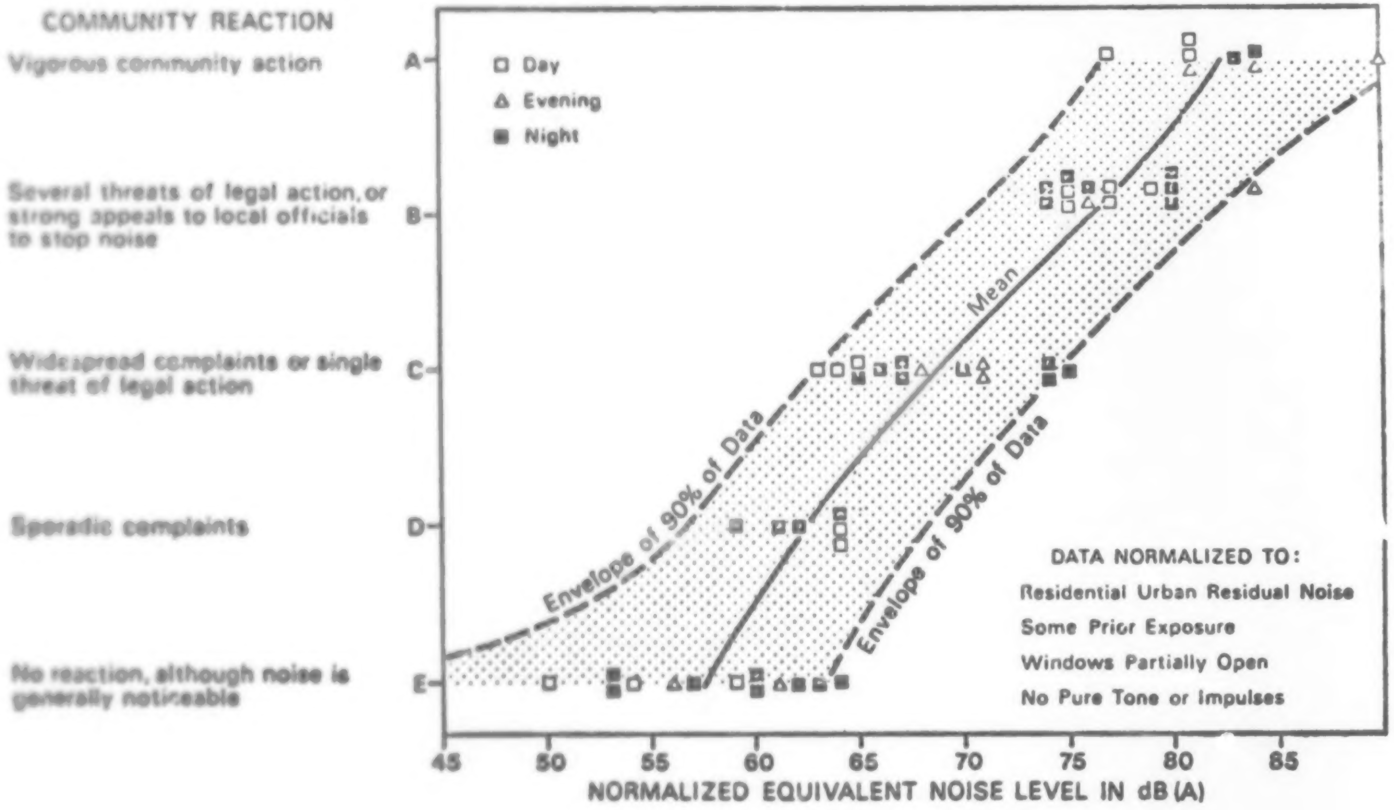

Figure 3-1. Community Reaction to Intrusive Noises of Many Types.

Source: (3-4 page 66)

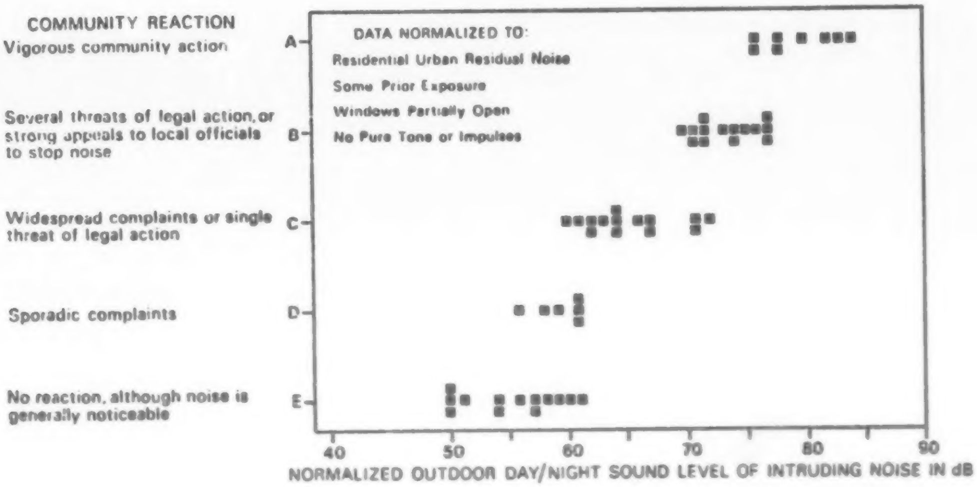

Figure 3-2. Community Reaction to Intensive Noises of Many Types as a Function of the Normalized Outdoor Day/Night Sound Level of the Intruding Noise, L_{dn} in dB(A).

Source: (3-4).

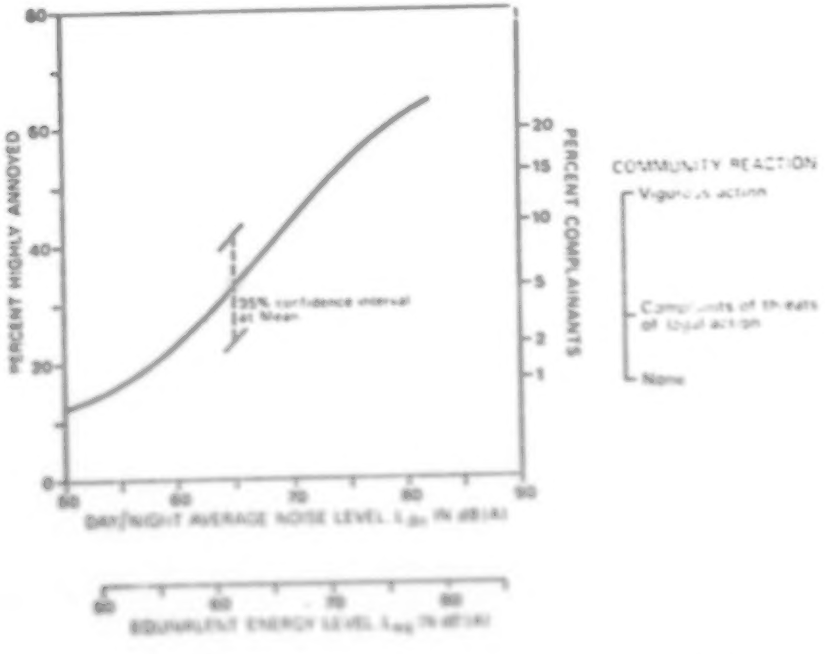

Figure 3-3. Intercomparison of Various Measures of Individual Annoyance and Community Reaction as a Function of the Day/Night Average Noise Level, L_{dn} in dB(A) and Equivalent Energy Level, L_{eq} in dB(A).

Source: (3-4).

3.2.1 Health Criteria

Many countries have nationally-issued positions on the cause and effect relationships between levels of environmental noise and adverse effects on people*. One of the better-known ones is the "Criteria Document" issued by the U.S. EPA in 1973. (3-2)

Other countries have similar works or have incorporated assumptions into noise standards.

A recent OECD study summarized the environmental noise effects as follows:

> "Effects of Noise
>
> It was said that noise at the levels at which it normally occurs in the urban environment does not usually lead to any identifiable (or significant) direct physiological harm. The current medical evidence is that non-impulsive noise at levels below 75 dBA (L_{eq}) probably causes no lasting direct physiological damage to the human body. Work by the United States Environmental Protection Agency suggests there may be some very slight hearing loss to normal adults in industrial noise situations after ten years exposure to daily 8-hour continuous levels of 75 dBA (L_{eq}), although a British Government code of practice accepts that exposures of up to 90 dBA over an 8-hour working day limits the risk of "significant" hearing loss to a very small proportion of the exposed persons and some experts do not regard traffic noise of this level as a risk to hearing (because traffic noise does not contain very loud peaks). According to a survey carried out for the United States Environmental Protection Agency fewer than 10,000 people in the United States are exposed in their residential surroundings to outdoor day/night average sound levels above about 86 dBA (L_{dn}), and fewer than 500,000 to levels above 80 dBA

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* The same holds true for occupational noise, but these criteria are covered in Chapter 8 on "Occupational Noise".

> (L_{dn}). Allowing for the noise attenuation provided by house structures, it can perhaps be inferred that the risk that urban dwellers may suffer hearing damage due to noise exposure outside their occupational surroundings is probably very small, although complacency in the present state of knowledge could not be justified.
>
> Apart from direct hearing damage, noise may have indirect physiological and psychological effects. Interference with sleep typically begins to occur at levels of about 35 dBA. It is not clearly established how far this interference, which need not amount to prevention of or arousal from sleep, affects the subsequent well-being and performance of the sleeper. Interference with normal speech communication is present at about 55 dBA and this aspect of noise intrusion contributes both to subjective annoyance and loss of performance. There is the easily entertained suspicion that feelings of severe annoyance aroused by noise may contribute to overall "stress" and so to stress-related conditions such as heart disease or mental disorders. In this case direct "sound arousal" effects are less likely to be more significant than subjective responses to the source of the noise, e.g. feelings that the noise could be more efficiently controlled or even, in the case of aircraft noise, fear of aircraft crashing. "Significant" noises such as human voices or music may be subjectively just as annoying as much louder noises of an inanimate kind. It is worth noting that, conversely, actual hearing damage may result from noise to which people voluntarily expose themselves. Thus, it has been found that industrial workers are sometimes reluctant to take measures to protect themselves against very severe occupational noise, and one may also mention the suggestion that some amplified pop music may perhaps cause hearing damage." (3-1, p 4)

As to the extent of the noise problem and its intensity on the people in different countries the same OECD reported in October 1975 the following figures as contained in table (3-2) and figure (3-4).

Noise Level Ld in dB(A)	Belgium	Federal Republic of Germany	Japan	Luxembourg	Spain	Switzerland	United States	Seven Countries
50	86	87	91	85	88	84	89	89
55	68	72	80	67	74	66	76	76
60	39	46	58	37	50	38	52	49
65	12	18	31	11	23	12	24	24
70	1	4	10	1	7	1	6	7
75	0	0	1	0	1	0	1	1

Table 3-2. Percentage of Population Exposed to a Noise Level Equal to or in Excess of a Given Value.

Source: (3-4)

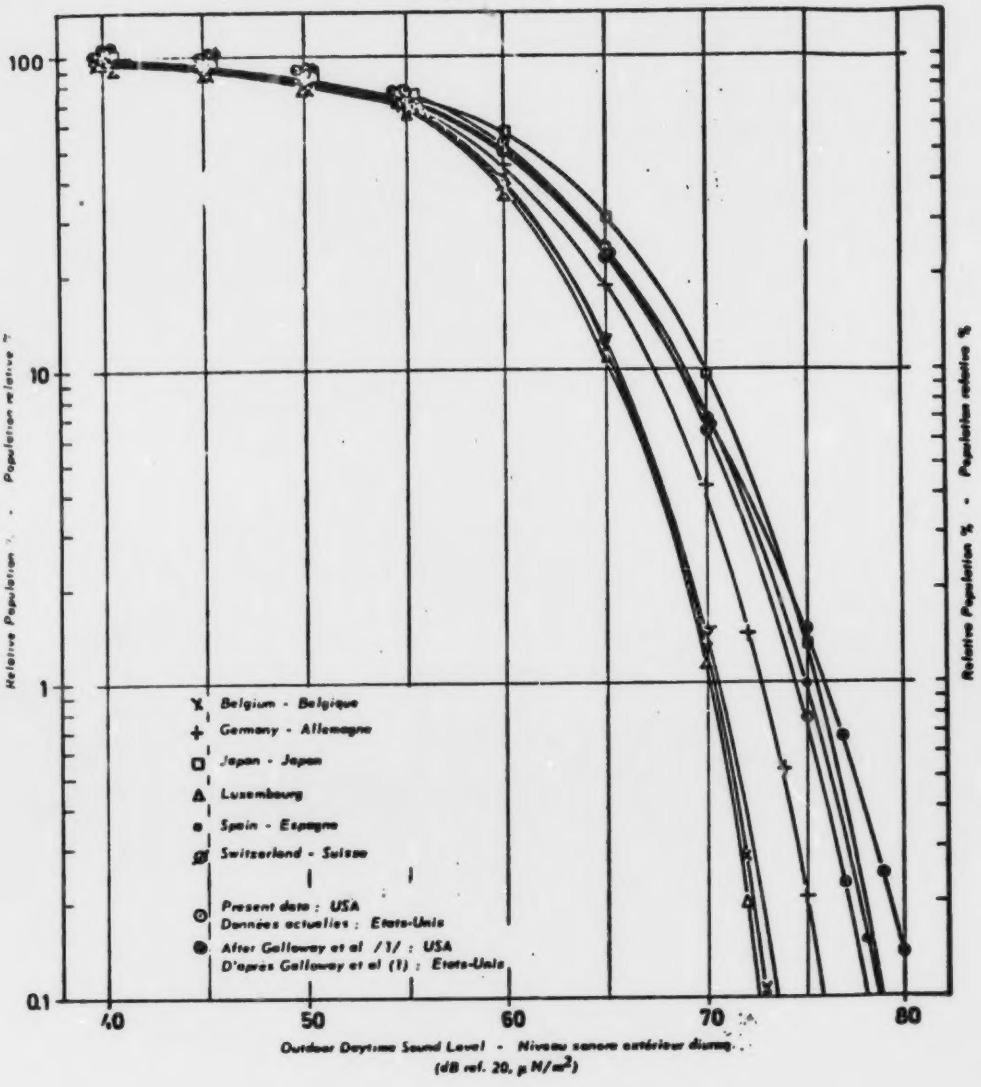

Figure 3-4. Percentage of Population Exposed to an Outdoor Daytime Sound Level of or Above a Specified Value.

Source: (3-4).

3.2.2 Survey Results

3.2.2.1 Complaints and Annoyance

English General Community Survey (The Wilson Report)

Virtually every survey ranked noise from surface traffic as the most prominent single factor in the urban noise environment. However, the figures from a 1968 British survey (Table 3-3) show that surface traffic is by no means the only source of annoyance:

Description of Noise	Number of People Annoyed Per 100 Questioned		
	When at Home	When Outdoors	When at Work
Road traffic	36	20	7
Aircraft	9	4	1
Trains	5	1	-
Industry/construction work	7	3	10
Domestic/Light appliances	4	-	4
Neighbors' impact noise (knocking, walking, etc.)	6	-	-
Children	9	3	-
Adult voices	10	2	2
Radio/TV	7	1	1
Bells/alarms	3	1	1
Pets	3	-	-

Table 3-3. Sources of Noise Annoyance in England.

Source: (3-7)

While the absolute percentages vary from community to community, the foregoing list is fairly typical. The same noise sources appear repeatedly, augmented from time to time by sources of particular concern in certain localities: river boat whistles on the Danube, motor boat exhausts on Swiss lakes, radios in Russian apartment complexes, etc. On the question of urban vs. rural disturbances, a clue is given by data from a poll of 1600 people in Norway (Table 3-4).

	Number of People Annoyed Per 100 Questioned		
		Area	
Type of Noise	All Questioned	Urban	Rural
A. Noise from motor vehicles	17	20	11
B. Noise from aircraft	3	4	1
C. Noise from railroads	4	5	1
D. Noise from neighbors	5	6	3

Table 3-4. Sources of Noise Annoyance in Norway.

Source: (3-8)

More recent surveys continue to confirm that road traffic noise is the chief factor in community annoyance (3-1, p. 8).

The Swedish-Italian study

The percentage of people annoyed by the same noises is likely to vary as a function of national life style. It is true that the train noise annoyance studies already described coincided well for the United Kingdom, Japan and France. On the other hand there is the now-famous Swedish-Italian study.

This comparative study with a sample population (matched in terms of age, social, and occupational status) of 200 people in Stockholm and 166 people in Ferrara, Italy, came up with a statistically significant difference -- 92% in Stockholm versus 63% in Ferrara spontaneously mentioned traffic noise, and 61% in Stockholm versus 43% in Ferrara were disturbed by traffic noise. The conclusion was drawn that results concerning annoyance reactions to traffic noise in one country cannot be directly extrapolated to another. (3-9) See also the Japanese and the French Train Noise Surveys in Chapter 5, "Surface Noise" of this report.

3.2.2.2 Noise Surveys

3.2.2.3 Noise Standards

Besides investigating criteria, many countries have gone one step further and issued suggested levels of noise that should not be exceeded if the public health and welfare (including freedom from annoyance for most of the population) are to be preserved. We shall refer to such levels as "environmental noise standards" whether they are national laws or merely suggested guidelines.

Generalized desirable noise levels

One way to express desirable levels is in terms of total exposure of an observer in various settings. For example, Table 3-5 shows desirable levels identified by the U.S. Environmental Protection Agency, where annoyance is assessed on the basis of speech interference.

Table 3-5. Noise Levels Identified by the U.S. EPA as Requisite to Protect Public Health and Welfare

Effect	Level		Area
Hearing loss	$L_{eq}(24)$	70 dB*	All areas
Outdoor activity interference and annoyance	L_{dn}	55 dB	Outdoors in residential areas and other places where quiet is a basis for use
	L_{eq}	55 dB	Outdoor areas where people spend limited time, e.g. playgrounds
Indoor activity interference and annoyance	L_{dn}	45 dB	Indoor residential
	L_{eq}	45 dB	Other indoor areas such as schools

*On the basis of annual energy averages of daily level over 40 years; this level makes allowance for occupational exposure of up to 75 dB L_{eq} (8 hours).

A recent French compilation showed that in general, long range target standards adopted by other countries did not disagree with U.S. levels in Table 3-5. At the same time, typical existing outdoor standards of some countries were now about 10 dBA less stringent (equivalent to about L_{eq} = 65 dBA) than the long term goals, and it was recommended that the various existing country standards could and should be "standardized" at L_{eq} = 67 dBA outdoors and 47 dBA indoors:

> "In the United Kingdom, the following limits are prescribed: 50 NNI for airplane noise and 68 dBA L_{10} for ground traffic noise. The indoor noise shall not exceed 50 dBA, if construction is forced in a very noisy zone.
>
> In Japan, the limits are: 65 L_{eq} dBA during the daytime, evenings and mornings, 60 at night for ground traffic noise and 70 WECPNL for aerial traffic.
>
> In France, N = 84 threshold is retained for aerial traffic and L_{eq} = 65 dBA (8:00 a.m. to 8:00 p.m.) threshold for ground traffic.
>
> Taking into account the fact that L_{eq}, L_{10} and NNI are closely related, the cited limits can be assumed identical within 2 dB error. We propose to retain 67 L_{eq} in dBA as the outdoor noise level limit above which construction of dwellings can be authorized only under special safeguards. The indoor noise level in dwellings should not exceed L_{eq} = 47 dBA." (3-3 p. 26 + 27)

One International Criterion

ISO passed Recommendation 1996 in 1971. R 1996 uses a different decision criterion for identification of noise problems requiring action, a criterion based on prevention of annoyance and complaints due to a particular source rather than all of the noise sources acting together. The R 1996 principle has been incorporated in some national standards and thus passed on to localities. Although it suggests a "basic criterion" of 35 to 45 dBA (L_{eq}) outdoors in residential areas, in essence, its principle is that if a contemplated new source will not produce noise more than 10 dB greater than the sum of all the existing sources, widespread complaints are not to be expected in spite of what the new level may be. (3-11, p. 8) It is clear that while this method is useful for complaint prediction, it is not suitable as a noise standard, for if this principle alone was used without any absolute limits in addition, there would be nothing to prohibit community noise levels from increasing indefinitely. A creeping (gradually increasing) background level would be possible.

3.3 Direct Regulations

3.3.1 National

Some national land zoning schemes have legal force. See Table 3-5.

Finally, source emissions regulations imposed at the national level (or for Common Market countries, potentially the international level), may be a contribution to community noise programs on the one hand and a limitation on the other. There

TABLE 3-6

Comparative Table of Noise Emission Standard Values in Federal Republic of Germany and Selected European and Non-European Countries

Note: **As of now we have no specific laws for Belgium, Denmark, France, Holland and Norway, though noise abatement provisions are available in these countries at local levels, i.e. police regulations)**

Country Existing laws and regulations, in force since:	Industrial Area		Mixed Area		Residential Area		Criteria for establishing a standard or issuing a regulation
	Day	Night	Day	Night	Day	Night	
Federal Republic (L_{eq}) BIm Sch G (formerly Gewerleordnung) 1974 Industry: TA noise 1968 VDI 2058 - 1960/73 Construction: AVV constr. noise 1970 (emission like TA noise)	70	70	60	45	50	35	1. Avoidance and local acceptance versus noise. 2. Existing level of technology. 3. Exceeding the level up to 20 dBA. 4. No regulation on zoning; traffic noise and sound propagation are not taken into account.
Great Britain (L_{eq}) BS 4142 (1967) Industry: in preparation, similar to BS 4142	75	65	70	60	50 60	40 rural 50 urban	1. Consideration for traffic. 2. Older workshops have noise levels higher by 10 dBA (85/75 dBA)
Austria (L_{eq}) OAL directive 3 Bl.1 - 1972	70	70	60	50	50	40	1. Consideration for traffic. 2. Indoor values are lower by 5 dBA with open windows, by 15 dBA with close windows (3 and 4)
95% of OAL dir. 3 Bl.1 - 1972	60	60	50	40	40	30	

Table 3-6 (Continued)

Country Existing laws and regulations, in force since:	Industrial Area		Mixed Area		Residential Area		Criteria for establishing a standard or issuing a regulation
	Day	Night	Day	Night	Day	Night	
Sweden (L_{eq}) Environmental Protection Law 1969							Rules laid down from case to case (level of technology).
Switzerland (L_{eq})							1. Consideration for traffic. 2. Permissible day/night peaks, in certain curcumstances, higher by 10 dBA
USSR (L_{eq}) Laws (Industry): SN norm 1956 205-56 ff	"sanitary safety zone": day = 60; night = 50						1. Strict zoning. 2. Sanitary zones around industrial complexes. 3. Following the ISO TC-43. 4. Ruling from case to case (level of technology). 5. Consideration for traffic. 6. Permissible peaks higher by 25 dBA
SN norm 1965 535-65	60 70	50 rural 60 urban			45 50 60	35 suburb 60 rural 50 urban	
USA - New Jersey only (L_{eq})		day = 65		night = 55			Only one level for the day and one for the night time.
Japan Noise Control Law for Industry & Construction 1968	70-65	65-55	65-60	55-50	50-45	45-40	1. Strict zoning. 2. Consideration for traffic.

Note: Japanese limits are not exact counterparts for dBA limits but for moderate and high levels (> 50 dBA) phon (A) and BA are roughly equivalent).

Table 3-6 (Continued)

Country Existing laws and regulations, in force since:	Industrial Area		Mixed Area		Residential Area		Criteria for establishing a standard or issuing a regulation
	Day	Night	Day	Night	Day	Night	
ISO (L_{eq}) ISO R1996	70-60	60-50 55-45	60-50	55-45 45-35	45-35	35-25 30-20	1. Consideration for traffic. 2. Departs from basic values of 35 or 45 dBA allowing for traffic and industrial noise and deducing 10-15 dBA for night time. 3. For noise levels lasting less than 56 percent of the total, lower limits are proposed. 4. Noise peaks may exceed not more than 30 dBA.

may be a limitation if they prempt localities who desire to enforce source noise limits stricter than the national ones.

3.4 Other Government Actions

3.4.1 National

One example of non-regulatory contributions from the national government to community noise programs is the criterion developed on the national level for local use. This topic has been covered in a preceding section. There are also other national non-regulatory actions.

Examples:
Model building codes
Model ordinances
Helping with measurement methods for enforcement
Environmental Impacts Statement Process.

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3-4 Commins, D. E. and L. J. Schreiber. Tentative assessment of the number of people exposed to varying noise levels in seven OECD countries. OECD Environment Committee Ad Hoc Group on Noise Abatement Policies, Paris, October 1, 1975.

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4. AIRCRAFT/AIRPORT NOISE

This section deals with noise control approaches other than source reduction of the noise from aircraft itself, which is presently being addressed chiefly at the international level by ICAO (see Section 2.1).

This section will cover such abatement topics strategies as:

4.1 Evaluation (Decision Criteria)

4.1.1 Criteria for evaluating the effect of noise around airports

4.1.2 Noise monitoring systems for airports

4.1.3 Estimates of numbers of people exposed

4.2 Regulations

4.2.1 Operational patterns (takeoff and landing procedures).

4.2.2 Curfews

4.2.3 Banning or limiting certain types

4.3 Other Measures

4.3.1 Noise taxes incorporated in landing fees.

4.3.2 Zoning near airports.

4.3.3 Purchase of houses to create

4. AIRCRAFT/AIRPORT NOISE

Aircraft noise poses a major environmental problem primarily near major airports. The most impact is felt in residential communities exposed to aircraft flyovers during takeoff and landing operations. The implications of this phenomenon are extremely complex especially in industrial countries with heavy air transport.

In their attempt to control or decrease the effect of aircraft noise near airports different countries have taken different approaches and measures ranging from operational to zoning plans. It is the purpose of this section of the report to examine the extent of this noise problem and to explore the different measures and plans undertaken by various countries to deal with this issue.

4.1 Evaluation (Decision Criteria)

4.1.1 Criteria For Evaluating The Effect Of Noise Around Airports

Criteria for evaluating the effect of noise around airports has been made according to certain circumstances which are consequently different. To present an overview of various approaches to aircraft noise assessment, some criteria are presented. In Sweden, for instance, (4-1) the Swedish criteria for airport noise was presented in 1961 by a governmental investigation named "Flygbuller som samhallsproblem" (Aircraft noise as a social problem). The criteria given in this investigation is called "critical noise limit", CNL.

In the Netherlands (4-2) the extent of the aircraft noise problem is assessed by computing the noise contours around all existing airfields for various noise-load values and by subsequently computing the number of houses, schools, hospitals, etc. within these contours. The noise-load contours are expressed in so called Kosten-Units (KE);

these units were developed during a 6-year study in the mid-sixties and are closely related to the Noise and Number Index, used in the UK. Input data for the computations are based on the results of monitoring stations around the main airfields and a recent investigation of the noise characteristics of the military aircraft in use as well as on the flight characteristics.

More than 5% of the total land area is subjected to a noise load of 40 KE or more (corresponding with an Ldn 60 dBA), which is considered to be the maximum allowable noise load for new housing developments.

The impact of aircraft noise on people is assessed by using the results of aircraft noise surveys. The main survey was performed around Schiphol airport in 1963 but additional surveys and checks are regularly being made.

In Romania aircraft noise is determined by the effective perceived noise level (EPNL) in units of EPNdB. In the United Kingdom noise standards take into account any pure tones and also the length of time for which the highest noise levels are experienced. Accordingly they also are expressed in terms of EPNL. Meanwhile social surveys around Heathrow have shown that the daytime annoyance caused by air traffic depends on both the maximum perceived noise level (PNL) in units of PNdB and also the number of aircraft heard during a given period. The so-called noise and number index (NNI) combines both these quantities. Where traffic at a particular civil airport is busy enough for the setting up of an insulation grant-aid scheme covering nearby dwellings, the entitlement under it corresponds generally with the 55 NNI contour.

In Switzerland, aircraft noise is generally evaluated with the NNI. NNI curves have been developed for the large civil airports in the cities of Zurich, Geneva and Basel. About 4,000 people were interviewed during 1971 and 1972 on the subject of noise annoyance in the airport regions of Zurich, Basel and Geneva and valuable results were made out of that survey. South Africa, through the South African Bureau of Standards (SABS) has developed its own national standard codes of practice for measurement and assessment of aircraft noise at airports.

Table 4-1 gives an overview of the different criteria and assessment measures of aircraft noise at airports in different countries.

TITLE	ABBRE-VIATION	COUNTRY OF ORIGIN	DEFINITION	NOTE
Noise and number index	NNI	U.K.	$L_{PNmax} + 15 \log N - 80$	
Störindex	$\bar{Q}$	Germany	$(1/\alpha) \log (1/T) \int_0^T 10^{\alpha} Q(t)\,.dt$	1
Indices de classification	R	France	$L_{PNmax} - 16 + 10 \log (N/960) + 5 \log \xi$	2
Annoyance index	AI	Australia	$10 \log \sum 10^{L_{PNmax}/10}$	
Noisiness index	$\overline{NI}$	South Africa	$10 \log \sum \{K^2 (t/T) 10^{L_A/10}\}$	3
Noise exposure	L_{exp}	Netherlands	$20 \log \sum (k.10^{L_A/15}) - 106$	4
Aircraft exposure level	L_E	ISO	$10 \log \sum 10^{L_{EPN}/10} + 10$	

Table 4-1. Some National Aircraft Noise Exposure Indices.

Source (4-34)

Notes:

1. The value of α and the choice of the measure Q (t) are left free, but in practice the former is take to be 1/13.3 and the latter to be L_{PN} or L_A.
2. ξ is the annual average runway utilization factor.
3. K^2 is a time-of-day factor, 1 from 08.00 to 18.00 hrs.
4. k is a time-of-day factor, the same as K^2 in the South African formula.

4.1.2 Noise Monitoring Systems

The act of monitoring automatically constrains the aircraft into some kind of maneuver in order to comply. Microphones are stationed at certain distances from the end of the runways representative of community/airport interface regions. The purpose of the microphones is to monitor the aircraft noise on take-off, since it is considered to be the main source of noise disturbance. To achieve the noise level standard most aircraft have to reduce engine thrust over the monitoring positions which also means that a re-application of power is necessary some time later. Of course, variations in the perceived effects of noise levels exist according to day, evening, and night take-offs. Monitoring was first used at London and New York.

The second approach, and the one adopted at most major European airports, is based upon the estimated performance of a particular aircraft type or class of airplanes. Noise levels are set from this performance data, and the monitoring positions measure and record the actual levels.

The third system is one just being initiated by the State of California. This is the most comprehensive, and consequently the most complex to implement, and includes the concept of single flight monitoring, and the monitoring of a noise impact boundary. (4-5)

Presently, there are a number of monitoring systems in operation around the world. Most systems are automatic and computerized. When an aircraft exceeds the threshold noise level, it is identified and data is presented through an automatic print-out of the results which gives the maximum level of noise. In this respect besides mentioned cities, a short survey of countries seems necessary.

Aircraft noise monitoring exists at the following airports in France: Orly, Charles de Gaulle, Nice-Cote d'Azur, Bordeaux-Merignac and Toulouse-Blagnac.

Swiss airports have noise monitoring systems to assure that individual aircraft do not make excessive noise. The noise limits are based upon statistical distribution of typical flyovers. Warnings are issued to violators, and if an aircraft is repeatedly noisy, the airport authorities confer with the respective airlines. Geneva and Zurich use monitoring installations of the Hewlett-Packard type. (4-6)

In West Germany all the international airports are required to maintain monitoring systems. Frankfort is the only airport which assesses a penalty against the airline that violates the noise standard.

A monitoring system for aircraft noise is working at Arlanda, Sweden, and a similar system will be installed at Landvetter, the new airport in Gothenberg, which will be opened in 1977. Regular monitoring of aircraft noise is also carried out at fixed and mobile points.

Mobile noise measurement vans are operated in Canada in the vicinity of the Toronto and Montreal airports. In other regions inspectors take isolated readings with portable meters. (4-7) Mobile and fixed monitoring systems are also carried out at major airports in Australia.

Japan's experiment with aircraft noise monitoring systems is rather interesting since it operates according to a time zoning. With two and five noise monitoring towers installed in the vicinity of Tokyo and Osaka International Airport, respectively, aerodrome officials in charge work at the central observation station at each of the aerodrome to supervise the enforcement of various sorts of control measures for noise reduction and also record the data on noises.

At Osaka International Airport, under the above-mentioned noise supervision system, regulated noise levels of the noise volume classified by the time zone were established in February, 1970 on the basis of noise levels measured at the noise monitoring tower installed in the Kushiro Primary School located about 2.4 kilometers northwest of the airport. The airport authority has taken measures to prohibit such flights that threaten to cause the noise above the established, regulated noise levels as shown in Table 4-2.

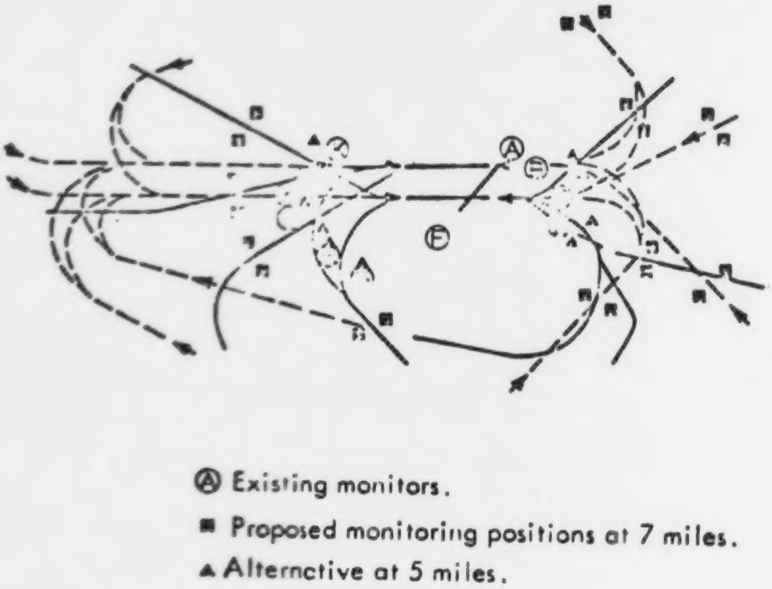
Time zone	6:30-7:00	7:00-2:00	20:00-22:30	22:30-6:30
Noise intensity (phons)	100	107	100 (107 in the case of landing)	75

Table 4-2. Noise Levels time - zones at Osaka International Airport. Source: (4-8)

As a result of the enforcement of these measures, aircraft for international service departing from this aerodrome have become subject to limitations on their "takeoff" weights and so, they have now been restricted by flying distance (4-8).

Concerning the noise monitoring system of the Heathrow airport in London, the following diagram gives an idea of the present and the proposed monitoring positions around that airport.

Figure 4-1. Proposed and Existing Monitoring at Heathrow Airport, London


Ⓐ
Ⓔ
Ⓕ
Ⓐ Existing monitors.
■ Proposed monitoring positions at 7 miles.
▲ Alternctive at 5 miles.

Source: (4-8, p. 15)

4.1.3 Estimates of People Exposed to Aircraft Noise

Although aircraft noise is not the largest source of noise nuisance, it affects a significant proportion of the population. The following table 4-3 gives a general estimation of number of people affected by sources of noise among which aircraft noise.

Mode	Numbers	Percent Population
Traffic	112 million	45
Aircraft	5 million	2
Industrial	74 million (intermittent exposure)	30
Railways	-not known yet-	

Table 4-3. People Exposed to High Environmental Noise Levels
Note: High Environmental Noise Level is not defined in the source.

Source: (4-10)

4.2 Regulations

4.2.1 Operational Patterns (takeoff and landing procedures)

An important element in noise control is to reduce the noise output of an airplane during a takeoff or landing maneuver, particularly over areas of high population density. In an attempt to minimize the effect of aircraft noise, a variety of operational procedures, in this respect, have been introduced around the world. Different measures and regulations have been made corresponding to certain elements existing at each particular airport. An overview of the different approaches some countries have made is presented.

Japan has taken different operational countermeasures to combat against aircraft noise. At Tokyo International Airport for instance, a measure was put forth to make all aircraft takeoff and land on the side of the sea between 10 a.m. and 7 p.m. Additionally, other countermeasures for improvement of aircraft operation systems are now in effect. The noise reduction climbing system (the cutback system) is designed to make the aircraft restrict its engine power over densely-populated areas. This system is now in effect at Osaka International Airport. (4-8, p 7)

Preferential runways for takeoff or landing of aircraft are specified to make aircraft takeoff or landing in areas less affected by aircraft noise. This system is presently in effect at Tokyo and Osaka International Airport and Matsuyama Airport. (4-8, p 8)

The Canadian Minister of Transport has specified noise abatement procedures for the operation of aircraft in the vicinity of the international airports at Vancouver, Edmonton, Winnipeg, Toronto, Ottawa, Montreal/Dorval.

London Heathrow has the so-called minimum noise routes for aircraft taking off. There are also preferential runway systems in operation in Zurich, Switzerland and Amsterdam (Schiphol), Netherlands. Canadian Ministry of Transport is considering the possibility of restriction of specified runways at some airports for usage only by quieter aircraft. (4-7, p 2-4)

As for Switzerland, a special instruction was issued on March 27, 1975, concerning "low drag-low power" technique of landing in order to reduce noise nuisance in the approach zones of airports. The text reads:

> During descent on IFR and VFR approaches an optimum clean configuration "low drag-low power" should be maintained as long as possible, i.e., landing gear, flaps, etc. should be extended as late as possible.
>
> Furthermore, cruising rmp should be maintained as long as possible in the case of aircraft equipped with variable pitch propellers.

> During ILS approaches the speed should be reduced on glidepath by extending gear and setting flaps gradually; however, when passing "Outer Marker" at the latest (in VMC at 500 FT AGL at the latest), landing configuration and proper approach speed should be established.
>
> During visual approaches the final approach should be carried out at an angle of not less than 3^{o}. (4-6 p 2)

This "low drag-low power" policy was introduced for the Swiss airports in compliance with the International Civil Aviation Organization (ICAO) recommendations (AN 1/54.3 - 73/220) of January 11, 1974. (4-15)

The Swiss government intends to re-examine the existing regulations on noise abatement for piston-engine aircraft with a takeoff weight of up to 5,700 kg For aircraft with a heavier takeoff weight, the standards established by the ICAO have been applied since 1972 . (4-9, p 2)

4.2.2 Curfews

Countermeasures against civil aircraft noise in some airports are in the form of curfews aimed at prohibiting the takeoff and landing of airplanes during certain hours (usually at night).

The Japanese government has taken a measure towards "prohibiting takeoff and landing of jet aircraft betweeen 11 p.m. and 6 a.m." at Tokyo International Airport in effect from December of 1962, and at Osaka International Airport in effect from November of 1965. Concerning Osaka International Airport the government took action to prohibit takeoff and landing of all aircraft, except for propeller-driven "midnight" mail planes between 10 p.m. and 7 a.m. (4-8, p 6)

In Germany, the airports have a partial curfew generally between 10 or 11 p.m. and 6 a.m. Swiss airports maintain restrictions from 10 p.m. to 6 a.m. When granting authorization for takeoff and landings of power-driven aircraft between 10 p.m. and 6 a.m., utmost restraint will be exercised regardless of the number of movements. Non-schedule commercial flights are restricted for movement at Zurich between the hours of 10 p.m. and 12:30, and for landings between 10 p.m. and 12 midnight. (4-6, p 3)

4.2.3 Banning or Limiting Certain Types of Airplanes

Certain types of airplanes are either banned completely from operation or are operated only on a limited basis determined by time, zones, or other factors. Due mainly to the noise effect on the environment many countries enacted regulations to prohibit planes flying sonic or supersonic flights.

Jet aircraft has been prohibited from landing or taking off between 11 p.m. and 6 a.m. at Tokyo International Airport since December 1962, and at Osaka International Airport since November 1965. (4-6, p. 6)

Supersonic flights are forbidden over Swiss air space, pursuant to Paragraph 14 of the Federal Law On Air Navigation, as of January 1, 1974. Federal regulation also forbids flying the SST in Switzerland and it is not certain that SST aircraft would ever be permitted to land in Switzerland even at subsonic speed.

In Canada pursuant to regulations issued on September 13 and October 1972, no person can operate a civil aircraft in sonic or supersonic flight unless authorization has been received from the Minister of Transport. (4-7, p 2-4)

Swedish authorities, for noise consideration, do not allow certain airplane models to land at Swedish airports. Also, for the same reason SST's are not allowed to fly at supersonic speed over Swedish territory. (4-11). The same negative attitude against supersonic flights also prevails in the Netherlands.

4.3 Other Measures

4.3.1 Noise Taxes Incorporated In Landing Fees

Some countries impose taxes on aircraft taking certain routes in landing or taking off. An example of this measure presently exists at Charles de Gaulle and Orly Airports in France. According to the Decree of February 13, 1973, a tax was imposed on air transport companies which was passed over to travellers using these routes. It was easier to collect taxes this way than to tax companies in direct proportion to the decibel level produced by their planes. Taxation by decibel level per company is being studied. (4-12)

4.3.2 Zoning Near Airports

Noise zones have been established in the vicinity of airports in many countries. In each zone, the land use is specifically prescribed in certain regulations and the noise level to each zone is usually determined by different surveys. The following survey of some countries will give an overview to what is being done in the area of noise zoning around airports.

Switzerland

Based on the NNI-Curves, noise zones have been established in the vicinity of the national airports. In each zone, the land use is specifically prescribed in a federal regulation. The respective NNI limits were confirmed by a large-scale sociological survey undertaken in Switzerland. (4-9)

Federal Republic of Germany

In order to protect the public against the effects of jet-aircraft noise, the Gesetz zum Schutz gegen Fluglaerm (Air Traffic Noise Control Act) has been enacted in April 1971. As a result, two zones of noise around jet airports (civil as well as military ones) have been specified. In zone 1 the equivalent noise level (L_{eq}) is higher than 75 dBA, while in zone 2 the noise level is between 75 dBA and 67 dBA. Noise at night is judged more serious than during the day. The zones are being calculated using complex procedures which include, among other factors, the types of aircraft using the airport and the routes. The zoning is based upon the estimated traffic result in 1981. There are several regulations as to these zones: no homes or apartment buildings can be built in zone 1. People who already live there can get up to 100 DM per m^2 (approximately 3.5 $\$/ft^2$) of their home for measures to protect them against noise (improved windows, doors, etc.). In zone 2 all newly constructed buildings have to be specially modified to protect against noise. No hospitals, schools, homes for the elderly, or the like are allowed to be built there. So far about half of the jet airports have officially been assigned noise zones of this nature. (4-13)

Romania

1) The Bucharest-Optopeni Airport region was zoned as a function of the value of the weighted equivalent continuous perceived noise level (WECPNL) in the following manner:

-- zone I WEPNL > 90

-- zone II 80 $\leq$ WECPNL $\leq$ 90

-- zone III WECPNL < 80

2) All inhabited regions in the vicinity of Bucharest-Otopeni Airport are located in acoustic protection zone III . (Figure 4-2)

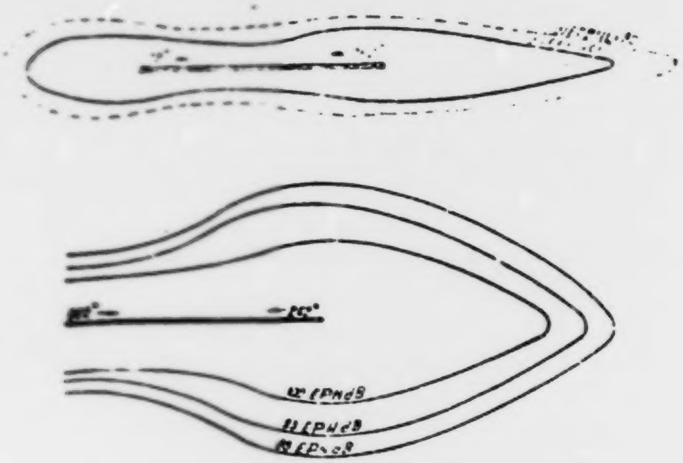


Figure 4-2. Noise zones in the Bucharest-Optopeni Airport, Romania.

Source: (4-14)

France

The Prime Minister's circular from July 30, 1973 establishes the principles of housing development in the area of airports. The idea is to restrict the construction of dwellings in zones which are, or will be in the near future, exposed to excessive noise levels. Of particular concern are wayside and riverside communities near Charles de Gaulle and Orly Airports. (4-12)

Japan

Pursuant to Article 9 of the Basic Law for Environmental Pollution Control Measures, Environment Agency Notification of December 27, 1973 was issued establishing the following measures to control noise around Japanese airports according to the following standards and within this time schedule contained in the following Table (4-4).

Table 4-4. Environmental Quality Standards for Aircraft Noise
Based on Article 9, Basic Law for Environmental Pollution Control Measures.
Environment Agency Notification, December 27, 1973

Category of Area	Standard Value (in WECPNL)
I	70 or less dB
II	75 or less dB

Note; Prefectural governor shall designate the category of area. Area category I stands for the area for exclusively residential use and area category II for other area where normal living conditions should be reserved.

$$WECPNL = \overline{dB(A)} + 10 \log_{10} N - 27$$

Note: $\overline{dB(A)}$ stands for energy means of all peak level of any one day, and N stands for a value calculated by the following equation: $N = N_2 + 3N_3 + 10(N_1 + N_4)$, where N_1 is the number of aircraft between 0:00 a.m. and 7:00 a.m., N_3 the number between 7:00 p.m. and 10:00 p.m., and N_4 the number between 10:00 p.m. and 12:00 p.m..

"N_2 is the number between 7:00 am and 7:00 pm"

Target for performance of standards

Airport Categories	Target Dates	Inprovement Goals
Airport to be built in future	Immediately	- - -
Existing Airports		
Third class and equivalent airport	Immediately	- - -
Second calss airports except Fukuoka Airport (A)	Within five years	- - -
d.o. (B)	Within yen years	Within five years to attain less than 85 WECPNL (or 65 WECPNL or less indoors in areas exceeding 85 SECPNL)
New Tokyo International Airport	d.o.	d.o.
First class airports (excepting New Tokyo International Airport) and Fukuoka Airport	As soon as possible within ten years or more	1. Within five years to attain less 85 WECPNL (or 65 WECPNL or less indoors in areas exceeding 85 WECPNL) 2. Within ten years to attain less than 75 WECPNL (or 60 WECPNL or less indoors in areas exceeding 75 WECPNL)

Notes:

1. "Existing" airports are those existing on the date of establishment of the environmental quality standards.
2. Airports of category B of second class are those where there are regular commercial landings and take-offs of aircrafts equiped with turbo-jet engines, and category A mean the other.
3. The dates indicated in Table 2 are to be counted from the date of establishment of the environmental quality standards.

Source: (4-15)

Canada

The Minister of Transport has calculated NEF contours for Canadian airports. These are used by the Central Mortgage and Housing Corporation to determine whether or not proposed dwellings near airports may be financed under the National Housing Act . (4-7)

4.3.3 Purchase of Houses to Create Buffer Zones and/or Subsidizing of "Soundproofing" of Homes

Countermeasures against civil aircraft noise were first taken in the form of measures to regulate aircraft operation such as the prohibition of midnight takeoff and landing. However, with the heavy increase in aircraft transportation and with the introduction of new aircraft such types of jets, it became necessary to take further measures to install soundproofing to homes in the vicinity of an airport or even to purchase them.

In Japan (4-8, p 9) pursuant to the Aircraft Noise Prevention Law, the Minister of Transport embarked on legislation regarding measures to compensate for troubles caused by the aircraft noise and in August, 1967, the Aircraft Noise Prevention Law was established and put in force.

Actual results of these compensation measures and the budget is included in Table (4-5)

In the Netherlands a pilot-soundproofing project involving some 500 houses is now being carried out in the Schiphol Airport area in connection with social surveys before and after the installation of an additional sound insulation (4-10) User changes are forseen to finance soundproofing and rehabilitations.

		Type of target \ Fiscal year	1967	1968	1969	1970	1971	1972	1973*	Total
Specific Aerodromes provided by the Government	Results of measures	(1) Noise insulation work								
		School, number	14 (7)	17 (14)	29 (26)	51 (40)	57 (49)	91 (70)	117 (84)	376 (290)
		Hospital, number	-	-	-	-	1 (1)	1 (1)	2 (2)	4 (4)
		Public utilization facility	2 (2)	2 (2)	5 (5)	11 (11)	13 (13)	20 (19)	31 (27)	84 (79)
		Private houses	-	-	-	-	-	-	400 (300)	400 (300)
		(2) Measures for TV reception, number of households	-	-	-	-	-	107,300 (85,000)	139,300 (85,000)	246,600 (170,000)
		(3) Compensation for removal								
		Land, ha.	-	-	-	0.59 (0.59)	1.3 (1.3)	4.53 (4.53)	5.59 (2.84)	12.01 (9.26)
		Structure, number	-	-	-	6 (6)	70 (70)	2 (2)	110 (100)	188 (178)
		Budget, ¥100 million	3.0 (2.4)	5.3 (4.1)	10.0 (7.5)	18.0 (14.4)	30.8 (27.8)	58.1 (50.8)	110.3 (88.1)	235.5 (195.1)
New Tokyo International Airport	Results of measures	(1) Noise insulation work								
		School, number	-	-	-	3	9	6	10	28
		Hospital, number	-	-	-	-	-	-	1	1
		Public utilization facility	-	-	-	-	-	4	6	10
		Private house, number	-	-	-	-	76	252	380	708
		(2) Compensation for removal								
		Land, ha.	-	-	42.7	49.4	50.6	32.7	50	225.4
		Structure, number	-	-	37	44	61	48	50	240
		Budget, ¥100 million	-	-	7.1	11.1	17.5	14.0	27.7	77.4

Notes: (1)* 1983's figures are estimated ones

(2) Figures in paranthescs for specific acrodromes provided by the Government are those for environs of Osaka International Airport.

(3) One million Yen (¥) is approximately equal to $3333 U.S.

Table 4-5

Actual Results of Noise Insulation and Compensation For Noises in the Vicinity of Aerodromes in Japan

Source: (4-8, p 23)

4.4 Helicopters

Helicopter aircraft noise has received attention in some countries while others have already taken measures to control it.

Thus, in Switzerland, since September 19, 1975, a special working group has been studying the problem of noise emission standardization for helicopters, following the policies of an overall reduction of aircraft noise for every type of aircraft. Although helicopter noise has presented no specific noise problem, Switzerland already has strict rules on helicopter traffic in residential zones. These permit landings only for emergency delivery of patients to hospitals.

In the Netherlands, no specific rules for helicopter noise exist. However, helicopter noise is a growing concern, especially in view of the rapid industrial development in the North Sea area where helicopters perform an important transport and communication role. (4-16).

In South Africa, helicopter operations are tentatively controlled and restricted where necessary pending the development of accurate techniques for noise zoning. (4-4)

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5. SURFACE TRANSPORTATION NOISE

The disturbing effects of transportation noise have become a major environmental problem. The intensity of the problem is more noticeable in urbanized areas where the rapid growth of different types of transportation has resulted in traffic noise as a social problem.

Man, in his struggle against this problem, has used different ways and means to assess the extent of its detrimental effects on human health and also has utilized different measures in an attempt to reduce, abate or control noise and its consequences on the human environment. The purpose of this chapter is to explore the methodologies used by other countries to develop criteria for the noise problem and to assess various technical measures, actions, remedies, laws, or regulations undertaken to bring noise limits to a reasonable level.

5.1 Decision Criteria

5.1.1 Decision Criteria - Road Traffic

As the foundation of any regulatory action, it is critical that legislative bodies of governments be provided with information regarding the quantitative basis of traffic noise regulation, required noise standards, noise reduction levels and technical and economical feasibility of such noise control actions.

5.1.1.1 Assessing Noise Levels

Assessing Single Vehicles - Measurement

To assess noise levels of single vehicles, a number of countries have used different means to develop several scales for assessing noise emitted by motor vehicles. In the process, many elements have been taken into consideration such as environmental, technological and economical feasibility. Other factors relating to the size, weight, speed, structure, and type of vehicle are also weighed. Together with surveys, research and tests, correlations have been established to assess and determine the extent and limit of noise from single motor vehicles.

The ISO standard for measurement of noise has been widely adopted by many countries. With the exception of one Swiss stationary test, virtually all foreign regulations use the ISO reference test ISO R-362, adopted in February 1964, as a measurement standard. This method is designed to measure noise from all types of motor vehicles. The acceleration test, at full throttle from a stated running condition, is designed to measure the "highest noise level consistent with normal driving". * The principle difference between ISO-362 and the U.S. SAE standards is that the SAE measuring distance is double that of the ISO distance. (R-362 is 7.5 m or about 25 ft. and SAE is 50 ft. from the center line of travel of the vehicle).

Among the other differences, the most important is the way the running condition is stated: A condition of SAE J-366 is speed at the end point of the measurement area, whereas the ISO R-362 method limits the initial speed before acceleration to a maximum of 50 km/hr. (31 mph), but sets no explicit limit on speed at the end point of the measurement area. However, in practice, the selection of an intermediate

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*There is also a stationary test. See next page.

gear speed makes it unlikely that the final speed would ever be in the range where tire noise would become significant.

Another difference is that whereas J-366 specifically is designed to produce maximum noise by insuring that acceleration while the vehicle is in the measurement area proceeds to maximum rated engine rpm, the ISO method will not get the engine to maximum rated rpm in every case. ISO R-362 is due to be revised soon. However, the basic procedure will not be changed; only the wording of various sections will be clarified.

ISO Stationary Test. -- Appendix A1 of ISO R-362 contains a stationary test method which is not presently used in any national regulations. Noise is measured at four points each located diagonally 7 m away from a corner of the vehicle.

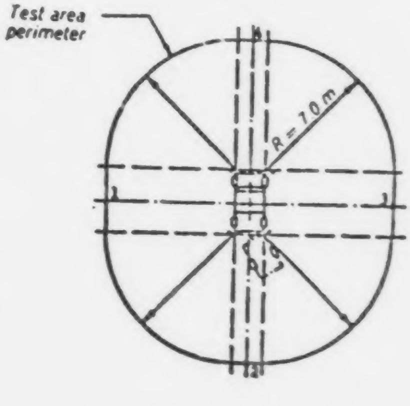

Figure 5-1 Measuring Positions for Measurement with Stationary Vehicles.

The engine is run either 1) at three quarters of its maximum hp rpm, if it has no speed governor; or 2) at maximum governed speed, if it has a speed governor.

There doesn't appear to be good correlation between ISO Reference Test results and ISO Stationary Test results.

The Swiss have been using a similar stationary test. This test also does not exactly correlate with results of the ISO Reference Test.

Some European countries feel that there exists sufficient correlation between the two tests so that the Stationary Test could be made an alternative to the Reference Test. However, the general view is that the Stationary Test should only be used for preliminary screening of vehicles in use.

Single Vehicles Data Sample - Sweden

Vehicle noise is measured individually in Sweden in connection with the approval of new designs but not as yet in connection with the inspection required of every single vehicle as part of the registration procedure. Consequently, no thorough review is made of the sound levels of new trucks, the overwhelming majority of which are inspected according to the latter procedure. Noise from trucks and cars in the urban environment has been determined, however, in a number of field surveys. In one study the difference between the maximum sound level of trucks and that of cars was found to be 8-10 dBA. The truck is the individual noise source for which silencing measures are most urgently needed.

Buses of earlier models are about as noisy as trucks, Figure 5-2 shows the results of measurements carried out on buses in regular service in the Stockholm area. Modern town buses are often far more silent running. For example, there is a Swedish built "silent" bus which does not emit sound levels higher than 77 dBB, measured as per ISO R362.

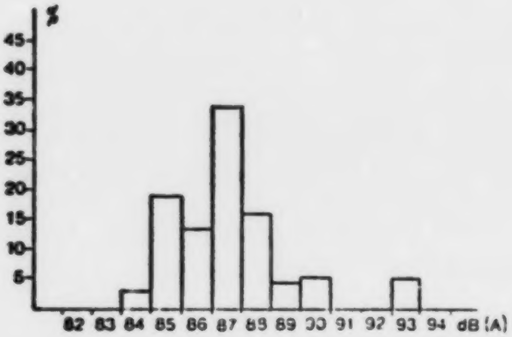

Figure 5-2 Percentage Distribution of Noise Levels for Service Buses in the Greater Stockholm Area (200 DIN HP) Measured as per ISO R362 for Moving Vehicles.

Source: (5-1, p. 18)

The sound levels of new cars are checked during the inspection of new models and designs. Figure 5-3 shows the result of measurements carried out on about 300 vehicles in 1972 by the National Road Safety Board, which is responsible for the inspection of vehicle designs.

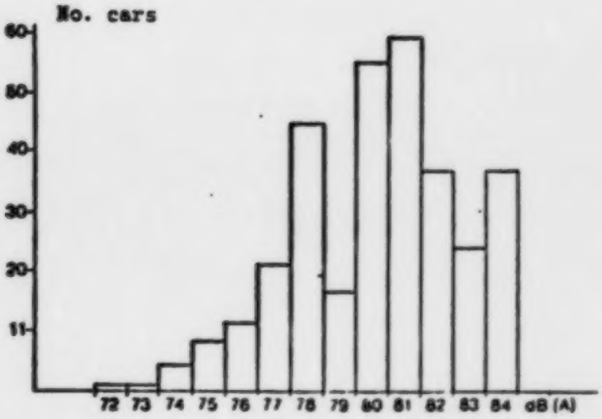

Figure 5-3. Sound Levels for Cars, Measured During Design Inspections in 1972.

Note: Noise was measured as per ISO R362 with the vehicles in motion. It should be noted that 84 dB(A) the maximum permissible noise level for the approval of the silencing arrangements of the vehicles inspected.

Source: (5-1, p. 18)

The majority of motorcycles are submitted to registration inspection, which means that at present their noise emission is not measured though the law stipulates that they must be provided with efficient silencing arrangements.

Figure 5-4 shows the sound levels of 52 motorcycles undergoing design inspection. Corresponding data for mopeds are given in Figure 5-5.

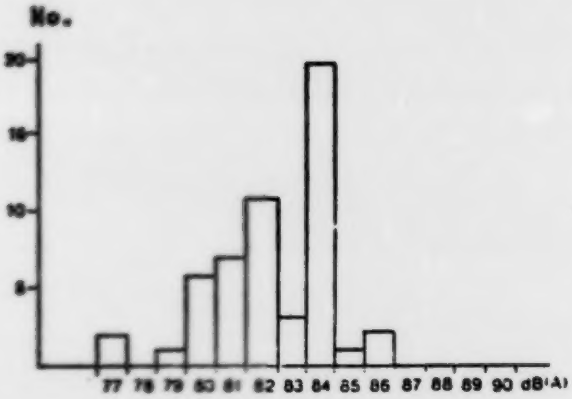

Figure 5-4. Sound Levels of Motorcycles, Measured as per ISO R362 During Design Inspection.

Note: It should be observed that the applied maximum limit is 86 dBA.

Source: (5-1)

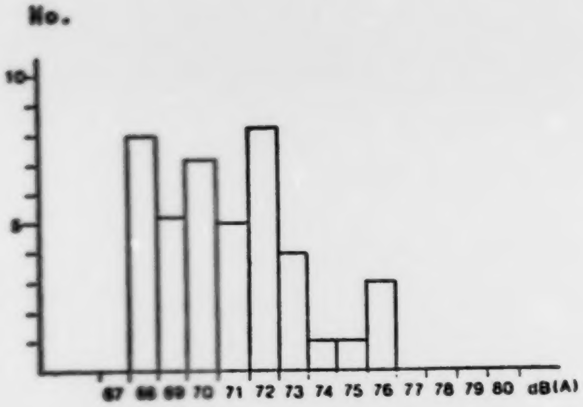

Figure 5-5. Sound Levels of Mopeds, Measured During Design Inspection.

Note: The mopeds were driven in top gear and at top speed, i.e. 30km per hour.

Source: (5-1)

Measurements of stationary vehicles were undertaken in Sweden. Table 5-1 shows the results of these measurements, which included both new and second-hand vehicles.

	Satisfactory exhaust syst.				Defective exh. syst.			
Type of vehicle	No.	Min.	Max.	Mean	No.	Min.	Max.	Mean
Motorcycles	44	78	101	93	7	94	114	104
Cars								
Front engine	170	73	94	82	37	82	99	90
Rear engine	28	78	95	89	5	92	101	95
Lorries								
≤ 200 DIN HP	60	85	99	92				
> 200 DIN HP	39	93	106	97				

Table 5-1. Results of Noise Measurements Carried Out on Stationary Vehicles.

Note: The method of measurement involved placing the microphone 50 cm. from the end of the exhaust pipe, whereupon the engine speed was raised from idling to a certain constant speed.

Source: (5-1)

Assessing Traffic Noise

Surveys, research studies and experiments have been initiated by many countries for assessing and predicting traffic noise along roads and highways. In determining traffic noise levels, various approaches and formulas have been developed. In this section traffic noise estimation and prediction in some countries are discussed.

In Japan road traffic noise is assessed by the following methods:

In March 1975, the Technical Committee of the Acoustical Society of Japan published a report on the method for estimation of road traffic noise. This method is applied to free flowing traffic, for example the case of a free motorway or equal road. Here, starting from the equal interval traffic model, a calculating formula was derived for sound level L_{50}. In Japan, L_{50} is now used for the evaluation of road traffic noise in environmental standards and other regulations. A-weighted sound power level and its relation with vehicle velocity were determined by the field investigations. Vehicles were divided into three kinds: heavy vehicles, light vehicles and passenger cars. Effects of the road constructions on the traffic noise propagation were also included in this method by considering the diffraction at the edge of the road. Excess attenuations due to the ground surface absorption and air absorption were not included explicitly, but correction terms due to these and other factors were applied in a lump, by comparing the results of this calculation with those of field investigations. (5-3)

In order to improve the accuracy of estimation, many basic research works have been carried out in Japan. As to the calculating formula, other traffic models were introduced, for example, exponential distribution of vehicle intervals and sound power level of each vehicle. In these studies, the calculating formula was derived not only for L_{50} but for other evaluation values such as L_{eq}, L_{10}

Scale model experiments have been widely used for the evaluation of road traffic noise, especially in cases of complicated road constructions, roadside geographical positions and urban streets. Incoherent line sources or moving point sources are used for the sound source in these experiments. Hybrid simulation methods (combining the scale model experiments and computer calculations) were also applied to these investigations. Also, the effect of meteorological conditions on the sound propagation are now being investigated by the scale model experiments and field investigations. (5-3)

In the Netherlands the following formula has been developed, based on previous investigations, from which the traffic noise produced by motorways can be approximately calculated: (5-5)

$$L_{eq} = L'_{7,5} + 10 \log N - 10 \log V - 10 \log A - 7{,}5 - D$$

in which

L_{eq} = the equivalent sound level in dB(A)

$L_{7,5}$ = the sound level of motor-vehicles measured at a distance of 7,5 m from the source, in dB(A)

N = the number of vehicles per hour

V = the speed of vehicles in km/hour

A = the distance to the road in m

D = a term in which the local conditions influencing among other things sound absorption and proofing, are taken into account

From this investigation it has further appeared that on an average for

passenger cars	$L_{7,5} = 63 + 0{,}16\ V$
trucks	$L_{7,5} = 72 + 0{,}16\ V$
trucks with trailers	$L_{7,5} = 74{,}5 + 0{,}16\ V$.

In Denmark traffic noise is measured and calculated on the basis of L_{eq}, dBA , 24 hours average.

Norway has developed one graphical and one computerized method for the calculation of noise levels. These methods also take into consideration the effect of structural devices to reduce noise. A simple method by which noise levels in streets can be calculated is being developed. (5-6)

In Sweden several studies have been carried out to determine the disturbing effect of traffic noise. A government report on measurement of traffic noise has proposed a combination between several different measuring actions which comprises noise origin and diffusion conditions (5-7)

A prediction model for traffic noise has been established for local conditions in South Africa for annoyance and impact of traffic noise, L_{10} is being used to qualify complaints and to establish guidelines for new roads. The South African Bureau of Standards document SABS 097-1975 "The Measurement of Noise Emitted by Motor Vehicles" (5-8) is the method used to assess noise emissions from individual vehicles and is based on ECE practice.

5.1.1.2 Assessing Effects of Noise On People

Because of the rapidly increasing number of motor vehicles on roads and streets, more than ever people are subject to the effects of noise exposure. Repeated daily exposure to traffic noise over many years may cause various adverse effects ranging from permanent hearing loss, to sleep disturbance, and other health problems to interference with conversation. To assess the extent of problems associated with various noise levels, studies, research, and surveys have been undertaken by many countries. This section will present sample results of some studies.

In Sweden, two recent studies were conducted as follows:

1. Study of the Impact of Traffic Noise in the Municipality of Stockholm, 1975.

This study was carried out in eight housing areas with various traffic volumes (800-2,800 vehicles per day) and various proportions of heavy traffic (3-17%). Some 85 persons were interviewed in each area. Disturbances were evaluated by calculating the mean reaction in each area as the percentage of persons who were "seriously disturbed Exposure was measured by the equivalent sound level, L_{eq}, the level in dB(A) exceeded for 1% of the time (L_{01}), and the average maximum noise level in dBA from individual passing vehicles.

Analysis of the relation between exposure and disturbance showed that there was a relatively good correlation between the L_{eq} value and disturbances ($r_{xy} = 0.77$). The covariance between the disturbances and L_{01} was of the same order of magnitude ($r_{xy} = 0.78$). Closer analysis revealed, however, that disturbances were mainly determined by the frequency of heavy traffic. Thus it could be established a growing proportion of heavy traffic produced a wider diffusion of disturbance up to 1,200 heavy vehicles per day. On the other hand a further increase of heavy vehicular traffic up to 2,800 per day did not lead to a corresponding increase in disturbances. (Figure 5-6)

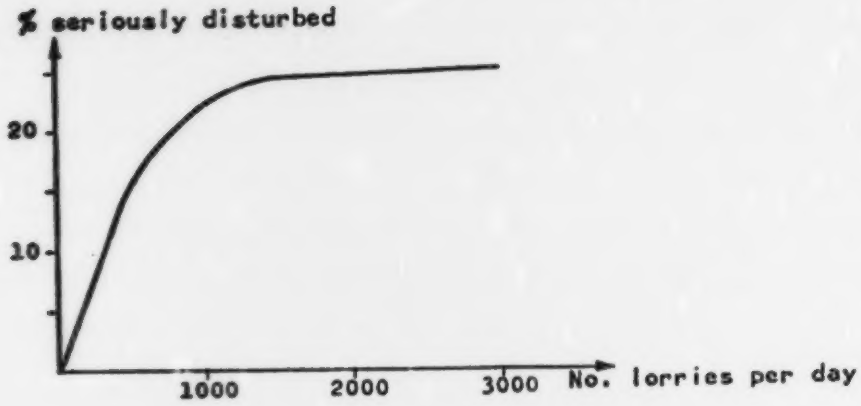

Figure 5-6. Relative Frequency of Seriously Disturbed Interview Subjects as a Function of Exposure Expressed in Terms of the Number of Trucks Emitting a Maximum of 80 dBA approx.

Source: (5-1)

So far this study has covered a relatively limited selection of experimental areas, and additional areas with different types of noise exposure will have to be investigated before any general conclusions can be drawn. These further investigations were carried out during 1976-77.

2. The Effect of Traffic Noise on Sleep, 1976.

In this study, EEG, EOG, EMG and ECG recordings were used to investigate the effect of traffic noise on sleep disturbance.

Introductory pilot experiments, which have been conducted in laboratory conditions, have shown that the disturbance of sleep tends to vary depending on whether the subject is exposed to noise from randomized truck passages with a peak level of 55 dBA or to steady traffic noise of the same equivalent level. The total of waking periods was found to rise by 7 per cent during nights with passing trucks, compared with reference nights characterized by "silent" conditions (27 dBA), but exposure to steady traffic noise at the same equivalent level (5 dB difference between minimum and maximum levels) resulted in an increase of only 3 percent.

Light orthosomnia increased by 5% in relation to the reference night during nights when there were lorries passing by. This occurred at the expense of deep orthosomnia and REM or parasomnia, each of which declined by 3%.

During nights of 40 truck passages, waking effects of various kinds were obtained in up to 70 percent of all passages; these effects varied from brief EEG and EMG changes to transitions between depths of sleep. Up to 18% of the passages caused the subjects to become completely awake.

The project is being continued in 1976 with a field study of an experimental group living in an environment where there is nocturnal traffic noise. The aim of the project is to determine the long-term effects of traffic noise on sleep.

In Denmark, the following results concerning nuisance due to traffic noise in Copenhagen were reported. (5-10)

Nine hundred sixty persons living in 28 different residential areas were interviewed. Half of the areas have an energy-equivalent, constant, A-weighted sound pressure level $L_{eq}(24)$ determined on a 24 hour-a-day-basis which is within the range of 46-58 dBA. For other half have a level which is within the range of 46-58 dBA. For reasons of simplicity these two groups will be described as areas with high noise exposure and areas with moderate noise exposure respectively. In the former group the noise exposure was determined by road traffic noise, whereas the road traffic noise was only a more or less determining factor for the noise exposure in the latter group.

The areas were paired in such a manner that one area with a high noise exposure and one area with a moderate noise exposure were as equal as possible in other respects, i.e.:

a) For the buildings: age, general look. size, and - if relevant - the flats, price level, etc.

b) For the residents: age, matrimonial status, school education, social status, number of children living at home, etc.

(only women were interviewed) who indicated that they were disturbed by traffic noise was 83% in the areas with a high noise exposure, whereas the percentage in the areas with moderate noise exposure was 13% only.

A detailed analysis of the situation in two corresponding (paired) areas, one in the group with a high noise exposure and the other in the group with a moderate noise exposure, is shown in Table 5-2.

Percentage of interviewed persons	$L_{eq}(24)$	
	72dBA	56 dBA
who indicated nuisance due to road traffic noise	97%	37%
having a high degree of physic well-being	30%	63%
who used sedatives	43%	23%
who consulted a doctor due to psychic problems	30%	3%
having interference problems when using the telephone	80%	3%
having interference problems when reading	70%	10%
who did not open windows (often or occasionally) due to road traffic noise	93%	17%

Table 5-2. Comparison of the Nuisance Due to Road Traffic Noise Found in a Danish Study.

Source: (5-10)

In England a pilot study was carried out at three of the Greater London Council housing estates to see what remedial measures can be undertaken regarding environmental conditions for residents when motorways or new major roads are constructed nearby. Table 5-3 shows the answers to a specific series of questions about perceived effects of traffic noise. (5-11) It should be noted that the answers give no indication of either frequency or degree of annoyance experienced, but they do illustrate clearly the effect of proximity to the road.

Percentage

Perceived effect of noise	*Study area*			*Control areas*	
	Area A (next to ramp)	*Area B (further from ramp)*	*Area A + B*	*Area C (next to road)*	*Area D (quiet area)*
Startle you/make you jump	57	10	36	24	10
Keep you from going to sleep	54	27	42	29	5
Wake you up	54	27	42	20	5
Stop your children from going to sleep*	(4)	(2)	(6)	(2)	(1)
Interfere with listening to TV, radio or records	86	33	63	49	5
Interfere with conversation	62	10	39	22	0
Make TV pictures flicker	86	40	66	57	13
Make the house vibrate or shake	89	27	61	63	15
Make you close doors or windows	86	27	60	63	5
Bother, annoy or disturb you in any other way	11	7	9	8	3
Total number of respondents	37	30	67	51	40

*This question was asked only of housewives with children under the age of 16. There were so few in this category in each area that the answers are not significant. However, as with other effects the reaction was strongest in Area A. The numbers given in brackets are the actual number of answers.

Table 5-3. Perceived Effects of Traffic Noise.

Source: (5-11)

5.1.1.3 Assessing Economic Impact

Information relating to costs of noise abatement and control in foreign countries has been limited and in most instances not available. Information regarding these costs is not precise. However, the following gives an overview of some aspects of noise control costs in foreign countries.

In the Federal Republic of Germany, the Federal Ministry of of Transport prepared the following cost estimates for noise barrier construction and sound insulation along newly proposed Federal aid highways. (5-12)

(a)

Noise Impact Threshold Values					Estimated Costs (1975)
	Day	Evening	Night		
L_{ST}	70	65	60	dB(A)	3 Billion DM (1.2 Billion dollars)
L_{ST}	65	60	55	dB(A)	8 Billion DM (3.4 Billion dollars)
L_{ST}	65	55	50	dB(A)	18 Billion DM (7.6 Billion dollars)

(b)

Noise Level Reduction	Cost/Kilometer of New MOT Highways
L_{ST} - 10 dBA	1.7 Million DM/kilometer (1.2 Million dollars/mile)
L_{ST} - 20 dBA	5.0 Million DM/kilometer (3.1 Million dollars/mile)
L_{ST} - 30 dBA	20 Million DM/kilometer (12.5 Million dollars/mile)

Table 5-4. Estimation of Costs of Noise Barriers and Building Insulation in the Federal Republic of Germany.
(a) Total costs for various degrees of quieting
(b) Costs per kilometer of new highway

Source: (5-12, p. 640)

In Sweden, the State Committee on traffic noise estimated the costs of implementing the Committee proposals (5-13) during the first 10-year period, up to 1985, at Sw. Cr. 500-700 million per year (about $111-$117 million per year) of which approximately half comprises costs for noise reduction measures to vehicles, and half the cost for abatement measures in zones between noise sources and auditors (barriers, replacement of windows, etc.). It is anticipated that the costs for the latter measures will be incurred from 1976 onwards, while the costs for emission limiting measures will first be felt at the end of the 1970's. On the basis of information received from the motor industry, the implementation of the first stage of the emission norms, covering vehicle models dating from 1979 onwards, has been calculated to increase the price of a private car by an average of Sw. Cr. 1.000 (about $222) and the price of a truck approximately Sw. Cr. 4,000 (about $866) with unchanged performance in other respects.

In the United Kingdom, the cost of implementation of British legislation for highway noise compensation has been high. The sum involved for 4.4 million homes subject to excessive noise would be currently some L3,300 million (6.6 billion dollars)

5.1.2 Railroad and Rapid Transit

5.1.2.1 Assessing Noise Levels

In order to reach acceptable noise levels emitted by trains and rapid transit systems, many countries have conducted surveys and initiated studies. These surveys and studies have been mainly concerned with the impact of such noise on exposed population living in areas affected by these means of transportation. This section attempts to provide a representative sample of this information.

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Federal Republic of Germany

The Following sample data was obtained for external and internal railway noise.

No	Type of railway vehicle	Type of track	Speed (km/h)			
			60	120	200	240
1	German Federal Railway	ballast bed, wooden sleepers	80	90	98	100
2	Passenger and Freight trains	ballast bed, concrete sleepers	78	88	(96)	(98)
3		ballast-free, concrete slabs	84	94	(102)	(104)
4		ballast-free, metal bridge	97	-	-	-
5		ballast bed, metal bridge	85	-	-	-
6		ballast-free, truss bridge	91	(101)	-	-
7		ballast-free, reinforced concrete bridge	82	(92)	-	-
8		ballast bed, reinforced concrete bridge	79	-	-	-
9	Rapid transit system	ballast bed, wooden sleepers	72	79	-	-
10	underground, on open air line	ballast bed, wooden sleepers	72	-	-	-
11	Elevated railway	ballast-free, concrete track	78	-	-	-
12	Tramway	ballast bed, wooden sleepers	77	-	-	-
13	Tramway	asphalt street	82	-	-	-
14	Tramway	ballast bed, reinforced concrete bridge	78	-	-	-

Table 5-5. Typical External Railway Noise Levels

Noise level of railway vehicles at a distance of 25 m from the centre of the track, measuring height 3, 5 m above the top of rail. Free propagation of sound. Faultless rail surface and wheel tread.

Source: (5-2)

Sample Internal Railway Noise Data

No	Railway vehicle	Noise Level dBA Speed (km/h) 60	 120	 200
1	Semi-fast, slow train, 2nd class	61	70	-
2	Fast train, 1st/2nd class	59	68	-
3	Inter-city train, open saloon, 1st class	59	68	74
4	Inter-city train, compartments, 1st class	56	65	71
5	Inter-city train, dining car	59	68	75
6	Fast train, couchette coach, 2nd class	58	67	-
7	Fast train, sleeping car, 1st class	51	60	-
8	Rapid transit system, 2nd class, in the open air	65	73	-
9	Underground railway in the open air	69	-	-
10	Rapid transit system, underground inside tunnel	74	-	-
11	Tramway	79	-	-
12	Diesel locomotive, inside driving cab	72	77-85	-
13	Electric locomotive, inside driving cab	68	77	-

Table 5-6. Noise Level (avg.) in Railway Stock. Ballast track. Faultless Rail Surface and Wheel Tread.

Source: (5-2)

5.1.2.2 Subjective Effects of Noise Levels on People

Japanese Train Noise Survey

A Japanese survey was made in 1971 to determine the effects of high-speed train noise on people living between 10 and 200 meters from the tracks. Noise measurements and interviews were conducted along both the Tokaido Line and the new Sanyo Line. At a maximum noise level of 70 dBA near the Tokaido Line, about 13 percent were disturbed in conversation and on the telephone, but 55 percent were disturbed listening to television or radio. Near the Sanyo Line, more than twice as many were distrubed in conversation and listening on the telephone but the interference with television and radio was about the same as on the Tokaido Line. At the maximum level of 70 dBA, 40 percent of the people near the Tokaido Line and 52 percent near the Sanyo Line rated train noise above the middle of the seven-point noisiness scale. Other results are shown on Tables 5-7 and 5-8.

French Train Noise Survey

A combination of social survey and physical noise measurement survey was done near Paris in 1973 (5-15). A questionnaire was designed and administered to 350 subjects living in different locations where the train noise was prevalent. Noise data included rate of increase of noise level, maximum noise level during train passage, (L_{max}), duration of audible train noise; duration of the maximum level L_{max}, rate of decrease of noise level, ambient noise level, and equivalent noise level L_{eq} over 24 hours.

The best prediction of annoyance, tested on noise alone was L_{eq}, whose value increased when either the number of trains or the noise of the train increased (correlation coefficient = 0.33).

Item	Line	Positive Response in %						Neutral Point of Scale
		60	50	40	30	20	10	
		dB(A)						dB(A)
Interference with sleep (30,31)	N.S.L.	80	78	75	72	69	66	78
	N.T.L.	87	84	82	79	76	74	85
Disturbance of hearing (32,33,36)	N.S.L.	75	72	69	66	63	60	73
	N.T.L.	78	76	73	70	68	65	76
Disturbance of children's life (43,44)	N.S.L.	82	80	77	74	71	69	77
	N.T.L.	89	87	84	82	79	76	85
Startle (35)	N.S.L.	84	81	77	74	71	68	81
	N.T.L.	88	85	83	80	77	75	86
Disturbance of falling in sleep (30)	N.S.L.	82	78	75	71	67	--	78
	N.T.L.	87	84	82	80	77	75	85
Awaking from sleep (31)	N.S.L.	80	77	74	71	69	66	77
	N.T.L.	87	85	82	79	76	73	85
Interference with telephone (32)	N.S.L.	79	76	73	70	69	64	78
	N.T.L.	81	79	77	74	72	69	78
Interference with listening to TV or radio (33)	N.S.L.	71	67	64	61	--	--	68
	N.T.L.	72	68	65	62	--	--	69
Interference with conversation (36)	N.S.L.	77	74	72	70	67	65	74
	N.T.L.	80	77	75	73	71	69	77
Bothering children (43)	N.S.L.	79	75	71	69	62	58	77
	N.T.L.	87	84	81	79	75	72	85
Disturbance of children's study (44)	N.S.L.	82	79	76	74	71	68	82
	N.T.L.	88	86	84	81	79	77	85

Table 5-7. Relationship between Proportion of Positive Response to Each Item and Peak Level of Train Noise

(N.S.L.: New Sanyo Line)
(N.T.L.: New Tokaido Line)

Source: (5-21)

Item	NNI 30			NNI 35			NNI 45			NNI 50			NNI 55 *		
	A	S	T	A	S	T	A	S	T	A	S	T	A	S	T
	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
Disturbance of falling in sleep	23	24	0	27	38	0	38	66	28	47	80	43	57	--	72
Awaking from sleep	41	20	0	47	39	0	60	76	30	65	95	48	70	--	67
Interference with listening to TV	43	53	34	51	70	49	72	100	81	75	100	88	79	--	92
Interference with conversation	36	26	0	45	49	7	68	94	56	73	100	80	78	--	100
Startle	43	10	0	48	28	0	58	64	25	59	81	44	61	--	64

* Values in Table 5-8 were obtained after comparing community responses to train and aircraft noise in NNI (Noise and Number Index).

Table 5-8. Comparison between Community Response to Aircraft Noise (Survey in UK) and to Train Noise in NNI

(A: Aircraft Noise, S: Sanyo Line, T: Tokaido Line)

Source: (5-21)

The criteria according to L_{eq} is shown in this figure and interpreted as follows:

> "It is seen that the proportion of favorable responses drops sharply and the proportion of unfavorable responses rises sharply as the value of L_{eq} increases above 72-75 dBA. At this exposure, 36.5% of the people responded with annoyance above the middle of the scale of overall annoyance. Accordingly, it was concluded by the French researchers that L_{eq} of 72 dBA represents a maximum acceptable exposure to train noise"

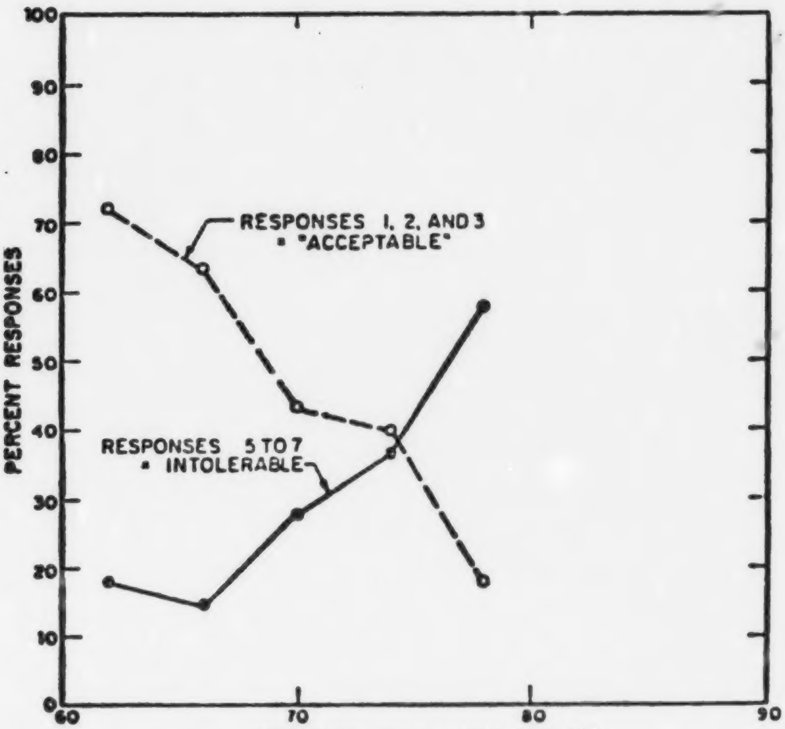

Figure 5-7. "Acceptable" and "Intolerable" Responses vs Equivalent Noise Level, with No Corrections for Exposure or Attitude.

Source: (5-16)

A predictive model was built that included non-noise variables like the number of rooms of the dwelling facing the track, attitude toward noise in general, attitude toward trains in general, and attitude toward the neighborhood. Use of these non-noise variables as well as the L_{eq} nearly doubled the ability to predict annoyance (correlation coefficient = 0.64).

The results of the French, Japanese, and also an English study suggest that the life styles of the countries agree sufficiently to allow conclusions drawn for one country to be applied to another, insofar as scaling of annoyance is concerned. (5-16)

Another result was that train noise does not produce as much annoyance as other equally intense environmental noise sources, possibly because of habituation to train noise, the fact that the railroads were often there before the adjacent occupants, and a positive attitude toward trains.

Japanese Laboratory Study

A laboratory study of the noisiness of trains was conducted in Japan parallell with the Japanese social survey. The purpose of the study was to define how the perceived noisiness (as opposed to expressed annoyance --- though presumably there must be some relation between noisiness and annoyance) depends on various parameters of the noise pattern during train passage (5-18). The study as reported by Schultz included tests carried out by presenting to trained observers a series of simulated and recorded train noises, having a variety of different peak levels, peak durations, rise and decay times, etc. These signals were alternated with a "Comparison Noise" whose level could be adjusted until the test noise and the comparison noise sounded equally loud.

It turned out that a satisfactory rating for the noisiness of train passages depends only on the maximum A-level during the train passage and the duration of the passage, thus lending support to the results of the survey. (However, despite the authors' claim that the noisiness is best predicted by the total energy in the noise of the passage, it is not; indeed, this claim is somewhat difficult to understand, since they state: "The rate of noisiness change, however, differs according as (sic) the energy change is caused by a change of peak level of noise or by a change of its duration, even if the energy changes are equal in both cases.

The formula that successfully predicted the judged noisiness was:

$$N = L_{A_{max}} + \frac{\left(L_{A_{max}} - 20\right)}{10} \log_{10}(T_d)$$

where $L_{A_{max}}$ is the maximum A-weighted sound level during the train passage and T_d is the time during which the noise level is within 10 dB of its maximum value. The duration dependence thus depends on the peak level, a relationship that hardly supports the claim that the noisiness of the train passage corresponds to the total sound energy in the event.

There is enough scatter in all survey results that this rather subtle dependence would likely be impossible to discover outside the laboratory". (5-16)

The general conclusion from these studies as far as the train noise is concerned and as stated by Shultz "... the best correlation with expressed annoyance is achieved when both the maximum noise level during train passages as well as the train traffic volume are taken into account; this can be done either explicitly, with separate terms for each variable (the NNI is an example, but not the best!), or by the use of L_{eq}, which embodies both variables. The prediction of annoyance is equally good either way". (5-16)

Swedish Survey

In Sweden, a study of the impact of train noise on exposed population groups is now in progress. So far two test studies have been carried out in order to formulate and test a questionnaire concerning train noise. During the spring of 1976, in an initial phase of the real study, interviews were conducted on some 400 persons living in four areas close to railways. These areas were selected in such a way that all respondents are exposed to the noise of about 100 passing trains per day, while the maximum sound level varies. The housing areas to be investigated are of relatively recent vintage. In a second phase, studies of areas are planned where traffic intensity is different and where the buildings are older, the aim being to investigate the occurance of or habituation effects related to train noise.

The first test study showed that the respondents did not experience specific noise characteristics. Instead annoyance seemed to result from the general noise emitted by the trains. Vibrations were a relatively common cause of annoyance. In the second investigation, 50 persons living next to a railway line were interviewed. Exposure varied between 62 to 80 dBA expressed as peak sound level, giving an equivalent sound level of 44-62 dBA. Twenty-five percent stated that they were greatly disturbed. These results correspond to those obtained in studies of the annoyance caused by aircraft noise. (5-1)

English Survey

A study was conducted in 1968 in England to evaluate annoyance to surrounding residents caused by the noise of the high-speed electric trains. The preliminary results as reported by Shultz suggested (to no one's surprise!) that people's annoyance decreases as their distance from the tracks increases, though the dependence was neither strong nor consistent. (As an example of this inconsistency, people living at 70 m distance expressed more annoyance than those at 45 m, according to one set of interviews.) There was a suggestion that people living in high background noise from other sources (children, dogs, etc.) are more sensitive to the railway noise than people in quieter locales, contrary to our usual expectations! This implies, perhaps, that in conditions of persistent noisiness, people experience an increased, rather than reduced, sensitivity to the occasional extra noise of the railroad. A similar trend was found in a French survey.

The British study very tenatatively concluded that the external noise level must exceed 95 dB(A) during train passages before serious annoyance becomes evident: this implies houses within 30 meters of the track. (5-16)

5.2 Noise Control Actions

5.2.1 Regulatory Activity

5.2.1.1 Direct Regulations

Proposed emission standards or norms do not have true practical value until they are established by legislation that can be enforced. Legislation has been enacted in various countries prescribing maximum levels of noise and methodology for monitoring these limits.

Source Emission Limits for New Vehicles

Members of The European community (Belgium, Germany, Italy, Luxemburg, France, The United Kingdom, Ireland and Denmark) have adopted emission limits in the Directive approved by the Council of the European Community of February 6, 1970. Limits are shown in Table 5-9.

Since 1966 all new types of motor vehicles in the Federal Republic of Germany have had to be tested by licensed institutions for their noise emission and whether they meet certain noise specifications. There are many technical details for measurements, depending upon the type of vehicle. Technical details are similar to the ones of ISO R 362. (5-24)

Noise level standards for motor vehicals have been established in the Netherlands. Every new type of motor vehical intended for use on the public highway must satisfy the required noise levels. Measurement methodology and instrumentation are established by law. The method of measurement was originally established by means of ISO Recommendation R 362-1964. Later, in 1971, EEC Directive No. 70/157 on the permissible noise level of motor vehicles was introduced into Dutch Law. (5-25)

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	Vehicle category	Value expressed
1.1.1	Vehicles intended for the carriage of passengers and comprising not more than nine seats including the driver's seat	82
1.1.2	Vehicles intended for the carriage of passengers, comprising more than nine seats including the driver's seat, and having a permissible maximum weight not exceeding 3.5 metric tons	84
1.1.3	Vehicles intended for the carriage of goods and having a permissible maximum weight not exceeding 3.5 metric tons	84
1.1.4	Vehicles intended for the carriage of passengers, comprising more than nine seats including the driver's seat, and having a permissible maximum weight exceeding 315 metric tons	89
1.1.5	Vehicles intended for the carriage of goods, and having a permissible maximum weight exceeding 3.5 metric tons	89
1.1.6	Vehicles intended for the carriage of passengers, comprising more than nine seat including the driver's seat, and having an engine power equal to or exceeding 200 HP DIN	91
1.1.7	Vehicles intended for the carriage of goods, having an engine power equal to or exceeding 200 HP DIN and a permissible maximum weight exceeding 12 metric tons	91

Table 5-9· Directive Approved by the Council of the European Community on Motor Vehicles and adopted by member states.

Source: 5-4

Notes: This Directive of 6 February 1970 deals with the approximation of the laws of the Member States relating to the permissible sound level.

This Directive applies to all motor vehicles intended for use on the road, having at least four wheels, with the exception of agricultural tractors and machinery and civil engineering equipment. This Directive is under revision at present. The revision proposal calls for a reduction of 2 to 4 dBA depending on the vehicle category.

Noise emission from individual vehicles in the United Kingdom was controlled through the 1973 Motor Vehicles (Construction and Use) Regulations. These regulations specified an acceleration test, with the maximum allowable level being 89 dBA for trucks and 84 dBA for automobiles, both measurements being made at 715 meters. The same Regulations provided also for roadside testing of in-use vehicles. Maximum levels for the roadside test, measured at no less than 5.2m. from the curb, are 89 dBA for automobiles and 92 dBA for trucks.(5-12) The present maximum noise limits for new vehicles are the EEC limits: and 84 dBA for trucks up to 3.5 metric tons, 89 dBA for trucks 3.5-12 metric tons, 91 dBA for trucks greater than 12 metric tons and 200 HP, etc., all at 7.5 meters. Manufacturers are required to certify that production models are similar to the prototype submitted for the type approval test. For in-use vehicle noise control through policing actions, stationary vehicle noise tests have been legally adopted. The law provides that the noise level of the vehicle being tested must be no more than 5 dBA over the maximum value allowed in its type approval test. (5-12)

The Federal Ministry of Transport of Canada has regulations limiting the noise emission properties at the time of importation or manufacture of new motor vehicles. Noise limits are specified in terms of the U.S. Society of Automotive Engineers recommended practices and standards and in terms of procedures of the United Nations Economic Commission for Europe (ECE). Accordingly, the permissible noise levels, measured at 15.2 meters are 86 dBA for light vehicles and 88 dBA and 83 dBA for light and heavy vehicles respectively.(5-28)

In Norway, regulations in connection with the Road Traffic Act for permissible noise levels are effective for motor vehicles certified for the first time after January 1, 1972. Norway participates in ECE's work in this field and the regulations are in accordance with ECE recommendations.(5-6) However, there are no emmission limits for road traffic noise in Norway, and no decision has so far been made to introduce legally binding regulations. As alternative to the latter is the introduction of guidelines for various areas and situations.

Other nations with source emission regulation based on the ECE or Common Market (EEC) recommendations are listed in Table 5-10. Japanese maximum allowable limits for automobile noise has been laid down in Article 16-1, Noise Regulation Law as presented in the following Table 5-11.

dBA

Timing	Classes of Motor Vehicle	Maximum Allowable Limits	
		Normal	Acceleration
Always	Medium, small and mini cars, and motor bicycles	85	
Certification test	Medium, small and mini cars (except motor bicycles and passenger cars with a capacity of less than 10 persons):		
	3.5 tons or more and 200 HP or more	80	92
	3.5 tons or more and 200 HP or less	78	89
	3.5 tons or less	74	85
	Passenger cars with a capacity of less than 10 persons	70	84
	Two-wheeled small cars	74	86
	Two-wheeled mini cars	74	84
	Class 1 motor bicycles	70	80
	Class 2 motor bicycles	70	82

Table 5-11 Maximum Allowable Limit for Automobile Noise. Article 16-1, Noise Regulation Law (Japan).

Source: (5-29)

Table 5-10 "Follows on next page".

	Authority/Name	Date Passed	Date to be in Force	Name of Meas. Std.	Comments
INTERNATIONAL	E. C. E. Reg. 9	15 Oct. 1968;		ISO R-362	Guildeline adopted by many countries.
		Rev. 1. 1973	26 March 1974		Revision 1 of 1973 changed limit for trucks over 12 mt and 200 hp from 92 dBA to 91 dBA, to confirm to E. E. C. (Common Market) limits.
	E. E. C. Dir. 70/157/E. E. C	6 Feb. 1970	6 Aug. 1971	ISO R-362	Common Market (E. E. C.) standard Once adopted by a member country, preempts corresponding parts of any national regulations.
	Amended by Dir. 73/350/ E. E. C.	7 Nov. 1973	1 March* 1974		1973 revision did not affect pass-by test.
NATIONAL	U. K. Reg. 29	1973		BS 3425 :1966	If EEC type-approved. Also 89 dBA for trucks over 30 cwt** unladen. All trucks first used after 1970.
	Japan Art. 30			ISO R-362	
	France		6 Feb. 1973	ISO R-362	Adopting the E. E. C. Directive.
	W. Ger.				Adopting the E. C. E. Directive.
	Italy	1 Mar. 1969			Adopting the old E. C. E. Reg. 9.
		1974			The E. C. E. Directive to be adopted in near future.
					* To be applied administratively in stages. See Art. 1-3, (Ref. 1) ** (30 cst = 3360 lbs, or 1.5 MT)

Table 5-10 Vehicle Emission Regulations

Source: (5-4)

(Continuation of Table 5-10)

Authority/Name	Date Passed	Date to be in Force	Meas. Std.	Comments
Sweden			SIS 025131	Adopting E. C. E. Reg. 9. SIS025131 equivalent to R-362.
Czech.	1971		CSN 300512	CSN 300512 equivalent to ISO R-362. Adopting the old E. C. E. Reg. 9.
Spain	11 Mar. 1970	1973	ISO R-362	Adopting the old E. C. E. Reg. 9. Will change to new Reg. 9.
Yugoslavia			"	E. C. E. Reg. 9
Norway		1972	"	
Australia /Design rule 28	July 1972	Gas-powered 7/1974 Diesel: 7/1975	like R-362	Voluntarily adopted by all states except Tasmania
Australia (Tasmania)		now 1 Jan 1975	BS 3425 :1966 "	

Zone-Type Regulations on Road Traffic Noise

The Japanese environmental quality standard relating to noise level was established on the basis of the Basic Law for Environmental Pollution Control and was approved by the Cabinet (May 25, 1971).

(a) General Area dBA

Category of Area	Division of Hours		
	Daytime	Morning & Evening	Night Time
	Not more than	Not more than	Not more than
AA	45	40	35
A	50	45	40
B	60	55	50

Note: AA - Areas which require particular quite. For instance, areas where medical ficilities are concentrated.
A - Primarily residential areas.
B - Areas in which a substantial number of residences are located among shops and factories.

(b) Areas Bordering on Roads dBA

Categories of Areas	Division of Hours		
	Daytime	Morning & Evening	Night Time
	Not more than	Not more than	Not more than
Type A areas bordering on a two-lane road	55	50	45
Type A areas bordering on a more-than-two-lane road	60	55	50
Type B areas bordering on a not-more-than-two-lane road	65	60	65
Type B areas bordering on a more-than-two-lane road	65	65	60

Note: Standard values vary depending on the area type. Therefore, classification of areas is left to the discretion of prefectural governors.

Table 5-12 Environmental Quality Standards for Noise Cabinet Decision on 25 May, Based on Article 9, Basic Law for Environmental Pollution Control Measures.

Source: 5-29

5.2.1.2 GUIDELINES AND PROPOSALS

(1) In the Netherlands, in anticipation of the realization of the Noise Act and the standards to be incorporated in due course, provisional limit values have been applied for some time. Thus, the immission recommendations for dwelling areas along motorways to be applied for the time being were set up in interdepartmental consultation in 1973. (5-31)

Limits Situation	Basic limit values to be applied provisionally to dwelling areas alongside motorways					
	L_{eq} in dB A					
	Outdoors		Indoors			
			partly opened window		extra front insulation and closed window	
	Day	Night	Day	Night	Day	Night
"new situations"	55	45	45	35	-	-
	60	50	50	40	-	-
"transitional situations"	60	50	50	40	40	30
	65	55	55	45	45	35

Table 5-13. Recommended Noise Immission Limits in the Netherlands

Source: (5-31)

In this table, a distinction is made between "new" and "transitional" situations. Besides there are "existing" situations. In "new" situations, the design, construction and the planning of the motorway, the residential quarter or both can reasonably still be modified in such a way that without extraordinary measures the recommended limit values can be met (e. g. a new development plan in which a residential quarter is projected close to a motorway).

In "transitional" situations the motorway or the residential quarter is already present and the design, construction or planning of the residential quarter along the motorway are already in such an advanced state that it cannot reasonably be expected that the modifications or provisions, necessary from an acoustic point of view, be fully met at short notice (e. g. a residential quarter under construction close to an existing motorway).

In "existing" situations both the motorway and the residential quarter are present.

Widening of existing motorways in the middle of residential areas is considered to be a "transitional" situation.

(2) In Denmark, limits of Danish guidelines with respect to evaluation of road traffic noise are shown in the following Table 5-14.

1	2	3
Urban area or Buildings	Satisfactory environment in case $L_{A,eq(24)} \leq$	Unsatisfactory environment in case $L_{A,eq(24)} \geq$
Rural residential and recreational **areas**	40 dB	50 dB
Suburban residential areas. **Recreational** areas in urban and **suburban** zones. Hospital zones	45 dB	55 dB
City areas with business, administration, etc.	50 dB	60 dB
Industrial areas for trade and **lighter** industry	55 dB	65 dB
Industrial areas for heavy **industry**	70 dB	80 dB

Table 5-14. Criteria for Road Traffic Noise.

Note: The table states when the environment can be considered satisfactory or unsatisfactory using L_{eq} on a 24 hours-a-day basis as a measure of the quality of the environment.

Source: (5-10)

(3) The Swedish Traffic Noise Committee proposed in August 1974 specific emission standards as well as immission standards. The immission limits are given in the following table. (5-15). As this table makes clear, the standards give one general, long term goal: desirable limits of 30 dBA indoors and 45 dBA to 55 dBA outside windows and in other outdoor areas.

The norms and standards proposed by the Committee can be considered as a specification of future legislation, and should as such facilitate the practical application of such legislation considerably. The Committee believes that this link can best be established by issuing the norms as recommendations and directives pertaining to the legislation. In this way, the rigidity desired in their application will be achieved, without the administrative procedures involved in considering exemptions and so on, which would result from legally binding norms issued as injunctions to the legislation (5-13).

Locality	Desirable Standard Limits		Exception I New area near major routes		Exception II New route in existing area		Exception III Upgrading of existing route		Exception IV Redevelopment of existing area		Exception for Existing Settlements	
Indoor premises	*Indoors*	*Outside windows*	*Indoors*	*Outside windows*	*Indoors*	*Outside windows*	*Indoors*	*Outside windows*	*Indoors*	*Outside windows*	*Indoors*	*Outside windows*
Dwelling	30	55	30	65(55)*	35	60	40	65	30	70(55)*	40	70
Health and educational premises	30	55	30	65	30	55	35	60	30	70	40	70
Educational premises type auditorium	25	—	25	—	25	—	30	—	25	—	35	—
Working premises for quiet activities	40	65	40	—	45	70	50	—	40	—	50	—
Outdoor areas	*Outdoor level*		*Outdoor level*		*Outdoor level*		*Outdoor level*		*Outdoor level*		*Outdoor level*	
Recreational facilities near all categories of premises in urban areas, e.g. parks and playgrounds	55		55		60		65		70		70	
Areas and zones for recreational activities	45		45		60		65		70		70	

*The parenthetic limits indicate that the level shall be achieved outside the windows of at least half of the rooms in a dwelling

Table 5-15 Immission Standards Proposed in 1974
Immission Limits in Equivalent 24-hour Sound Levels (dBA)

Source: (5-13)

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Proposed Swedish Emission Limits for Moving Vehicles

The Swedish Committee proposes that vehicles tested by the proposed method of measurement for moving vehicles should not be allowed to emit noise exceeding the following levels:

Measuring distance 7.5 m	Vehicle of model dating from 1978 or earlier dB(A)	Vehicle of model dating from 1979 or later dB(A)	"Second stage"—a proposed further decrease of allowed levels dB(A)	dB(C)
Private car	82	76	73	81
Truck or bus with gross weight not exceeding 3500 kg	84	77	75	83
Truck with gross weight exceeding 3500 kg				
≤ 200 DIN hp	88	83	80	88
> 200 DIN hp	91	85	80	88
Bus not covered below with gross weight exceeding 3500 kg				
≤ 200 DIN hp	86	80	77	85
> 200 DIN hp	89	81	77	85
Bus with gross weight exceeding 3500 kg used for scheduled services on routes passing mainly through urban areas	85	77	75	83
Two-wheel motor cycle with engine capacity:				
not exceeding 50 cc	78	74	72	—
greater than 50 cc but not exceeding 125 cc	86	81	77	—
greater than 125 cc but not exceeding 490 cc	88	82	79	—
greater than 490 cc	90	83	80	88
Three-wheel motor cycle	89	83	79	87
Cross-country scooter	87	81	78	86
Cross-country vehicle	91	85	79	87
	Vehicle brought into operation following inspection made before 1 July 1978 dB(A)	Vehicle brought into operation following inspection made 1 July 1978 or later dB(A)		
Moped	72	72	69	—
Tractor	88	84	81	89

Table 5-16 Noise Emission Standards Proposed in 1974

Source: (5-13)

As can be seen from the table, the norms have been differentiated by category of vehicle. The division is motivated first and foremost by the fact that the technical and economic feasibility of reducing noise varies considerably for different types of vehicles. This division was based, among other things, on surveys and on emission norms in other countries.

Regarding these norms, it is proposed that the first stage should apply to vehicle models dating from 1979. The norms for this stage should become obligatory by statutory processes and give limiting values which are approximately 5 dBA lower than those currently applicable in the EEC countries.

Proposed Swedish Emission Limits for Stationary Vehicles

The Swedish Committee proposed that the noise level from stationary vehicles, measured according to the methods proposed by the Committee, should not exceed the following values:

	Vehicle of model dating from 1978 or earlier dB(A)	Vehicle of model dating from 1979 or later
Private car Front-engined	91	For models dating from 1979 onwards, and vehicles not classifiable as any annual model, brought into operation following an inspection made 1 st July 1978 or later, a normal value in dB(A) shall be set in conjunction with the type, registration or moped approval. The value should not be set at a level which exceeds by more than 2 dB(A) the value measured at the approval. For a vehicle to be approved, in the annual safety inspection or any other subsequent inspection, the noise level may not exceed the normal value thus set by more than 2 dB(A). The normal value shall be stamped on a plate which shall be mounted on a readily-observable place.
Rear-engined	93	
Truck or bus with gross weight not exceeding 3 500 kg	93	
Truck with gross weight exceeding 3 500 kg		
≤200 DIN h.p.	97	
>200 DIN p.h.	104	
Two-wheel motor cycle	99	
Three-wheel motor cycle	93	
Cross-country scooter	99	
	Vehicle brought into operation following inspection made before 1st July 1978 dB(A)	
Moped	99	

Table 5-17 Proposed Swedish Limits for Stationary Vehicles

Source: (5-1 3)

5.2.2 Other Actions Beside Regulatory Actions

5.2.2.1 Vehicle Noise Reduction

Noise control technology aiming at reducing noise emission at the source has recently received more attention by motor vehicle manufacturers. A great deal of effort, research and funds are assigned for technical measures that would bring about more noise reduction as illustrated by the following examples from two representative countries.

Sweden

The Swedish motor manufacturers Volvo and SAAB have furnished particulars concerning the level to which noise emission can be reduced without altering the basic design of the various vehicles, and also concerning the costs involved in reductions to certain levels.

Cars

SAAB believes a reduction to 79 dBA measured as per ISO R 362 is possible. This will require the fitting of new, improved intake and exhaust silencers as well as screening off the noise generated in the engine compartment (encapsulation, sound-absorbent material). Volvo believes that a reduction to 78 dBA is attainable, which, given the variation occurring in mass production, means that the mean value for production will have to be reduced below 77 dBA. In addition to the above measures, Volvo refers to reduction of engine noise emission by stuffering the oil sump and the cam-shaft - transmission cover.

The Volvo and SAAB estimate that it will cost an additional Sw. cr. 200-250 (about $44-55) to bring the noise level of mass produced cars down to 80 dBA assuming that the same limit is applied in most other European countries. To this figure must be added increased service costs when replacing the exhaust system, as well as a marginal rise in fuel costs. (5-13)

The two motor manufacturing firms believe that the sound level of lorries can be reduced to 86 and 84 , measured as per ISO R 362, for heavy lorries (3,500 kg) with engine ratings of more than 200 HP and less than 200 HP respectively, without any laterations to the existing basic designs. To accomplish this, the following measures are necessary:

- introduction of a thermostatically cooled radiator fan
- screening devices along both sides of the engine compartment, with special extensions forwards and backwards
- sound-absorbent material together with oil protection and mechanical protection in the greater part of the engine compartment
- a tight-fitting and soundproof but easily fitted cover beneath the engine and radiator fan and parts of the clutch housing
- more efficient and much larger or double exhaust silencers
- more efficient intake silencers
- far more efficient water and oil cooling systems.

SAAB and Volvo state that if these measures were taken for the Swedish market only, the price of each vehicle would increase by about $881 (Sw. cr. 4,000). This increase will be halved if the same restrictions are introduced in their other markets.

Buses

Reference has already been made to a "silent bus," the CR 111M, manufacturered by SAAB. This model can keep within a maximum noise emission of 77 dBA. The requisite adjustments add about $1,444 (Sw. cr. 6,500) to the price of the vehicle and 350 kg to its weight.

Engines

Work is currently in progress in Sweden on the development of the Stirling engine. This project is being conducted by a specially formed company, United Stirling (Sweden) AB, under license from

Philips of Holland. One of the advantages of the Stirling engine is its low sound level. A 150 kW engine is estimated to have a sound level of 80 dB(A) or more. In a vehicle fitted with a Stirling engine, the engine itself becomes a subordinate noise factor. Instead most of the noise that is generated comes from the radiator fan and tires. A particular problem in this respect is posed by the fan compartment, since the Stirling engine transfers more heat to the cooling water than a diesel engine operating with the same output. United Stirling AB expects to have solved the problems connected with the Stirling engine by 1978, when mass production is planned to begin. (5-13)

United Kingdom

In the United Kingdom the Transport and Road Research Laboratory (TRRL) is currently involved in a 5-year quiet vehicle program designed to demonstrate the technical and commercial feasibility of quiet heavy traffic. The objective of the program is to produce two demonstration trucks, one 250 BHP and one 350 BHP, with noise levels of 80 dBA or less. The program is progressing in two stages. The first stage involves a coordinated effort among the TRRL, the Institute of Sound and Vibration Research, and the Motor Industry Research Association.

The Institute of Sound and Vibration Research has been investigating methods to reduce engine noise (to 77 dBA , gearbox noise (to 77 dBA and intake noise (to 69 dBA . Engine noise reduction is being pursued along two lines: increasing structural stiffness and damping. Methods being evaluated to increase structural stiffness include using stiff vertical crankshaft supports and incorporating an internal bearing beam in the crankcase frame. Increased structural damping is being investigated through the use of dampened cylinder block wall panels and a dampened sump fixed to the lower deck of the cylinder block.

The Motor Industry Research Association has been conducting research to reduce exhaust system noise (to 69 dBA) and internal truck cab noise (to 75 dBA in order to reduce user exposure.

Stage two of this 5-year program to be carried out by industry consists of the actual development and testing of commercially viable vehicles. (5-12)

5.2.2.2 Tire/Road Noise

Rolling noise has been indentified as a major source of annoyance to people living in the vicinity of high-speed roads. In an attempt to deal with this problem the extent and nature of rolling noise as a component of vehicle noise is being explored and studied in many countries.

The National Swedish Road and Traffic Research Institute has been engaged in this area of traffic noise problem through several projects: "Tire Noise Screening;" "Tire Noise--Influence of Tire and Road Surface;" "Tire Noise Recommendation Regarding a Measurement Method," and "Analysis of Vehicle Noise from Coarse Texture Pavements". (5-9) Another project presently in progress in Sweden is regarding tire noise measurement methods. The objective of this project is to obtain reporducible measurements of tire noise, to study the influence of different parameters on sound generation and to develop vehicle screens to prevent the diffusion of tire noise. The project is located in Stockholm and is being financed by the National Board for Technical Development. (5-1)

The Federal Institute of Road Affairs in West Germany has been active in tire noise generation research. Their research has revealed that car radial and bias-ply tire noise has a dependency on the fourth power of vehicle speed while truck tires fall in the range between the third and fourth power of vehicle speed. Additionally, the empirical studies indicate that noise levels are related to tire footprint width, noise spectra are independent of speed, worn tires without profile tend to be 2-3 dBA quieter, and rayon is quieter than nylon when used in tire construction. (5-12)

The Transport and Road Research Laboratory of the Department of the Environment of the United Kingdom has been concerned with research on tire noise and road surface effects on noise generation. The Laboratory reported the following results in the area of rolling noise. (Figure 5-8)

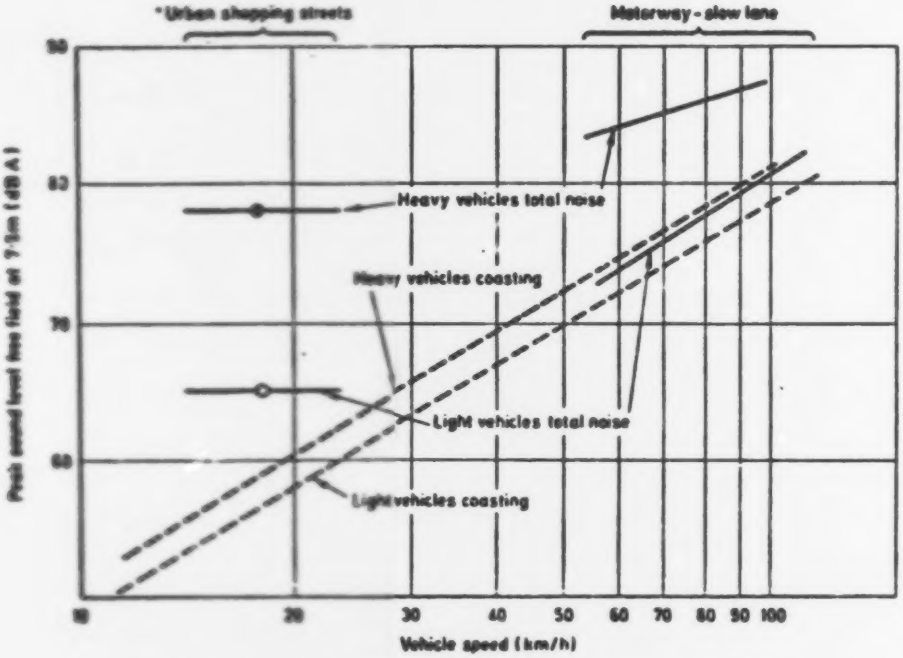

Figure 5-8. Total Vehicle Noise and Coasting Noise
Source: (5-17)

Figure 5-8 shows for an average light vehicle, up to 1.5 t, and an average heavy vehicle, over 1.5 t, how rolling noise and total noise vary under motorway conditions and in urban streets. For heavy vehicles in urban streets rolling noise is so much quieter than the total vehicle noise that it is unlikely to be noticeable. For light vehicles in urban streets and heavy vehicles on motorways rolling noise is about 7 dBA below total vehicle noise. This difference suggests that although rolling noise may not be the predominant source of vehicle noise, its contribution is not insignificant and changes of rolling noise will cause similar but smaller changes in total noise. For light vehicles running on motorways, rolling noise is only 2 dBA less than total noise and is clearly predominant. For this combination of vehicle and road any small change in rolling noise will cause an almost identical change in total vehicle noise.

In the U.K., annoyance from rolling noise is assessed by determining the level of L_{10} (18 hours). The derivation of levels on this scale from a knowledge of vehicle level and speed is not simple but the necessary computation has been accomplished using the Laboratory's computer model of traffic noise. The provision of a complete specification of L_{10} (18 hours) will require the derivation of predictive relations for the range of road surfaces typically encountered in the United Kingdom. An investigation to measure the basic vehicle noise data and to assess the safety as well as other aspects of road surfaces is presently part of a joint program with the Materials Division.

In the area of effects of road surface texture on noise the Transport and Road Research Laboratory has reported their findings. A coarse texture is incorporated into the surface of roads to provide drainage paths or channels which allow the dispersal of water in much the same way as the tread pattern on a tire. Provision of sufficient texture enables the skidding resistance of a surface to be maintained at high speed at a level similar to that available to low-speed traffic.

In the search for improved levels of high-speed skid-resistance it has become increasingly necessary also to consider the noise produced by traffic using the textured surfaces. A survey was therefore initiated in 1974, and subsequently extended, to provide information on the relation between noise and the effectiveness of surface texture in sustaining skidding resistance at high speeds.

Initial results have established that the noise from light vehicles increases with increasing texture both on bituminous and concrete surfaces although the relationship is different for the two types of construction (Fig. 5-9). With heavy vehicles, the tire/road noise is masked by the higher engine and transmission noise; they are not therefore discussed in this leaflet.

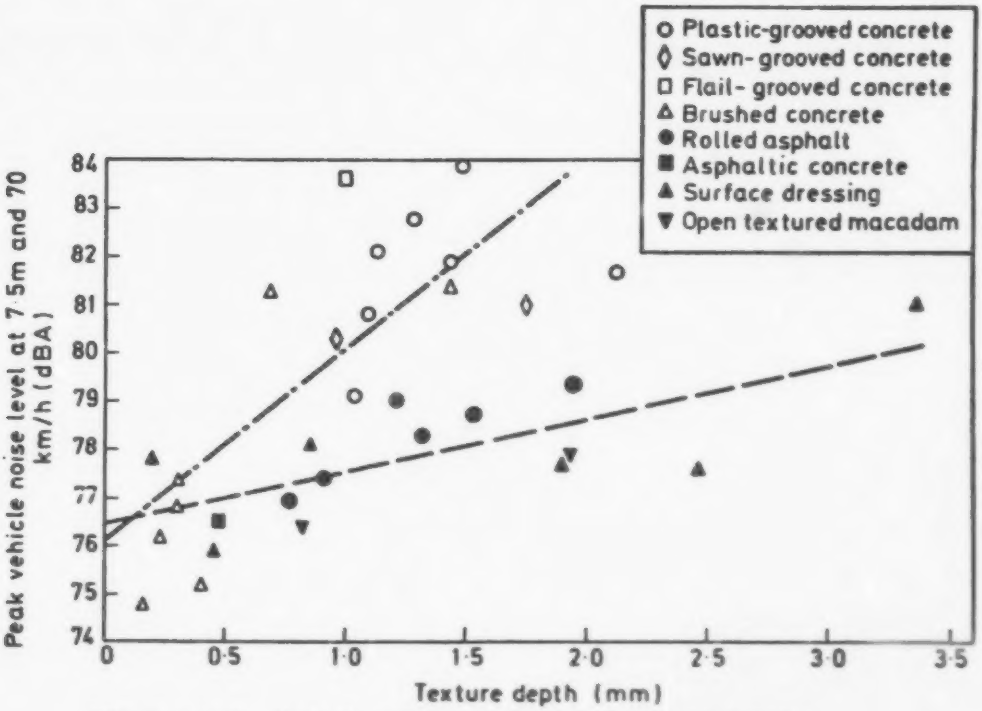

Figure 5-9. Relationships Between Texture Depth of Various Surfaces and Noise From Light Vehicles
Source : (5-17)

The effectiveness of texture in sustaining skidding resistance as speed increases has been found to differ according to whether the surface is concrete or bituminous. This is because texture on concrete is basically provided in a transverse manner whereas, on bituminous surfaces, texture is more random due to the distribution of chippings. By utilising established relationships the noise levels have been related to the effectiveness of the various surface textures in providing high-speed skid-resistance as defined by "the percentage change in BFC from 50 to 130 km/h." The resulting relationship (Fig. 5-10 demonstrates that, for light vechicles, the noise emanating from a road surface, of whatever type, is proportional to the effectiveness of that surface in maintaining the skidding resistance properties at higher speeds.

Further studies are being made to evaluate alternative forms of coarse texture in concrete surfaces and to distinguish between tire/road noise and mechanical noise from heavy vehicles. (5-19)

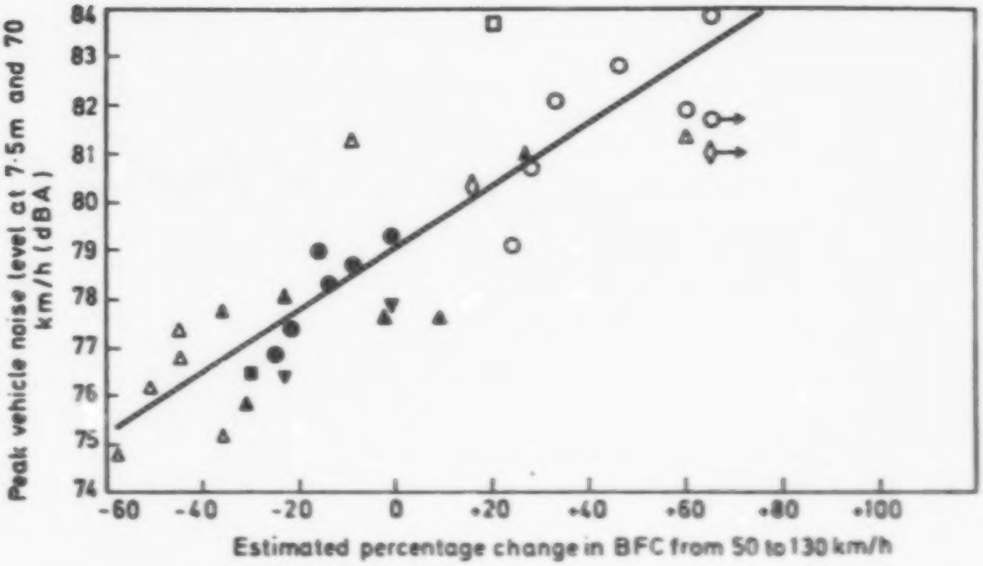

Figure 5-10. Relationship Between Estimated BFC of Various Surfaces and Noise From Light Vehicles

Source: (5-17)

5.2.2.3 Noise Screening

Noise screening is an effective measure in traffic noise abatement. Noise barriers have been constructed by many countries as a means of protecting inhabitants from noise. These barriers have different types of designs and are used for different noise abatement purposes. In their function they may be experimental, noise-absorbing or noise-reflecting. Their substance may include different materials such as wood, steel, plastics, concrete, earth or a combination of these and other materials. Performance of noise barriers reportedly varies.

Japan seems to be one of the most advanced countries in using noise barriers as a means of fighting traffic noise along highways. Presently in Japan, acoustic barriers are most widely applied to the road construction itself as noise control procedures. Many types of wall constructions have been developed and applied. Most of them are the panel type having necessary sound insulation characteristics and also having sound absorption on one side of the panel. Until the end of March 1976, the total length of barrier walls applied to the road bythe Japan Highway Corporation amounted to about 85 kilometers. Many types of barriers have been used resulting in some problems in the maintenance of the wall. So, Japan Highway Corporation is now preparing a standard type of barrier wall construction. In the case of important areas, acoustic shelters were applied to the road. In this case, of course, noise problems are solved except for noise radiation from the opening of the shelter as in the case of a tunnel. Here, the sound absorption treatments of the inner surface of the shelter or tunnel would play an important role for the control of noise radiated from the opening. (5- 3)

The following table provides a general overview of traffic noise barriers and their performance in reducing noise along traffic routes in European countries. (Table 5-18)

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Country	Noise Barrier Site	Location	Construction Materials	Length	Height	Noise Attenuation Estimation	Other Relevant Information
United Kingdom (Samples)	Noise Barrier-Site #1E	at Heston (near London)	Vinyl supported in a metal frame-work with sealed joints	300 meters	Varies from 2-7 meters to 3-3 meters	Noise reductions 3 dB(A) at first floor; 4 dB(A) at ground floor. House located at a distance of 20 meters from motorway	This is an experimental noise barrier erected in 1970 on a road carrying about 73,000 vehicles (30% heavy vehicles) in an 18 hour period.
	Noise Barrier-Site #2E	near Birmingham	Wood supported by concrete footings	about 1000	average 3 meters	Between 5-8 dB(A) averaged over an 18-hour period	
Switzerland	Noise Barrier-Site #1SI	South of Bern	Concrete		2.4 m (8 feet)	Not available	This type of barrier construction is claimed to be very practical, esthetically acceptable, durable and appeared to require little maintenance effort.
	Noise Barrier-Site #2SI	South of Bern	Earth		3-3.6 m (10-12 ft)	Not available	
	Noise Barrier-Site #3SI	South of Bern	Combination of materials		1.8-2.4 m (6-8 ft)	Not available	Constructed to protect single family residences. This barrier, it has been claimed, very effectively attenuated traffic noise, particularly since it would be designed for low, horizontal truck exhaust system.
France	Noise Shelter-Site #1F	South of Paris	Prestressed Corten steel shells separated by thick layer of glass wool	700 m		10 dB(A) during the day 15 dB(A) during the night	This noise shelter design covers the highway and achieved very satisfactory noise abatement results.
	Noise Barrier-Site #2F	Paris Beltway South of Paris	Concrete & steel framework	270 m	4-5 meters		Experimental noise barrier project has given the French valuable field information. Another noise barrier is being constructed in the same area and would be about 900 meters long, 9 meters high; estimated cost: 10.000 francs/meter (4,500$/yard).

Table 5-18. Noise Barriers in Some European Countries

Table 5-18 (continued)

Country	Noise Barrier Site	Location	Construction Materials	Length	Height	Noise Attenuation Estimation	Other Relevant Information
Sweden (samples)	Noise Barrier-Site #2SE	Southeast Stockholm	Combination of wood and earth mound	1,100 m	2-3 m	10-20 db(A)	
	Noise Barrier-Site #3SE	Southeast of Stockholm	Wood		2 meters		This barrier is constructed by the city on top of an access controlled highway cut section. It is meant to protect lower level and outside area of adjacent apartment buildings. It represents a combination of a highway cut, a barrier, and noise insulation.
	Noise Barrier-Site #4SE	Southeast of Stockholm	Wood and earth mound		8-9 meters		This barrier is also a combination of a highway cut, earth mound and wood noise barrier constructed mainly to protect apartment building from noise.
Federal Republic of Germany (samples)	Noise Barrier-Site #1G	Heumar, east of Koln	A series of: earth barriers, earth & wood, and absorbing plastic barriers.	about 1000 m	average 4 meters		Experimental project; constructed between 1970-79 to field test effectiveness, durability, esthetic qualities, weathering properties and other features of interest.
	Noise Barrier-Site #2G	Southwest Duisburg	Galvanised steel				This wall barrier combination will mainly attenuate ramp noise from trucks accelerating up the ramp grade to enter highway. It was constructed to protect apartment houses from traffic noise and vehicle headlight glare.
	Noise Barrier-Site #3G	near Duisburg	Painted steel	1,000 m	2-5 meters		This barrier was constructed along one side of the highway to protect adjacent single family homes.

Noise Barriers in Some European Countries

Table 5-18 (continued)

Country	Noise Barrier Site	Location	Construction Materials	Length	Height	Noise Attenuation Estimation	Other Relevant Information
Federal Republic of Germany (Continued)	Noise Barrier-Site #7G	East of Meckenheim	Steel	about 1,650 m	1.8-3.6 m (6-12 ft)		Finished in 1975; constructed along one side of the highway on cut and fill sections and vacant land planned for noise sensitive development. The front faces of the steel barrier panels were perforated with holes and the absorbing interior was filled with shredded rubber held in by a wire mesh and the back is solid.

Source: Information in this table has been based mainly on a report by Behrens, F. A. and Burry, T. M., "European Experiences in Highway Noise," Report No. FHWA-RD-123, November 1975, pp. 657-667.

Note: 1. in column 6 (Noise Attenuation Estimation) the distance from/to highway is not specified. However, we assume that it is of the order of 100 meters and at ground level.

2. The attenuation at ground floor was less than that at first floor because ground floor had already been partially shielded by the roadway elevation.

Noise Barriers in Some European Countries

5.2.2.4 Building Insulation Against Traffic Noise

The U.K. is the only country now actively compensating residents near highways for damage from road traffic noise. The payments are useable by the householder to partially pay for installing acoustic materials in the exterior shell of affected hours to alternate road traffic noise.

For further information on other aspects of this problem, see Chapter 6, "Noise in Buildings."

5.2.2.5 Planning and Zoning

In planning new roads in Japan, noise control procedures are now included as a design factor. Thus, in designing new roads, estimations of noise around roadside areas are derived from the traffic volume, mixture of heavy vehicles, average velocity and other factors, and the results of the estimation are compared with the Environmental Standards adopted for that area. If the estimated value is above the standard, several noise control procedures are applied in the design, such as alteration of road constructions, application of acoustic barriers, and institution of neutral green zones along the road. (5- 3)

In the Federal Republic of Germany where traffic noise is the most widely distributed source of noise, 18 cities have so far worked out the distribution of noise within their municipality, in the form of more or less complete noise mapping. This has been done on a purely voluntary basis. The maps usually indicate the various levels of noise using a bandwidth of 4 to 5 dBA. However, procedures for the technicalities have not yet been standardized. The purpose of these noise maps is to supply data for city planning. The Federal Government intends to make regulations for traffic noise similar to those for aircraft noise. The noise level along streets and highways yet to be constructed will be calculated based upon the estimated traffic result. (5-24)

In dealing with noise emitted by trucks, certain routes and time restrictions were designated for these type of vehicles. In this regard the city of Stockholm, Sweden implemented the following regulations specifically to reduce traffic noise:

1. No heavy trucks ($3\frac{1}{2}$ tons or over) were allowed at night (10 p.m. to 6 a.m.).
2. Long trucks (12 meters in length or greater) were restricted to use only designated highways and streets.

3. Heavy trucks were restricted to use designated truck routes.

Two specific cases are worthy of mention concerning the use of truck restriction to control highway noise in West Germany. All trucks over 7.5 tons are restricted from using a main highway between Bonn and Koblenz during the hours of 10:00 p.m. to 6:00 a.m. Secondly, trucks are restricted from using a local trunk road to bypass steep grades on a section of autobahn near Alsfeld in the State of Hessen.

In England, the British government, all counties, and the Greater London Council are working on plans for a national and local system of truck routes. In connection with this overall plan the GLC is working on establishing designated heavy truck routes in the London area in an attempt to regulate the traffic of heavy trucks on London streets by channeling them off of the most unsuitable streets and onto a network of main roads. At the same time, local areas needing special relief can be protected by banning trucks from entering unless they are needed to collect or to deliver goods. (5-12)

In some new French towns, Cergy-Pontoise about fifteen miles outside Paris is a case in point, a system of zoning is applied. Alongside motorways no housing is allowed on a belt 30 meters wide from the edge of the carriageway and apartments between 30m and 80m from the edge of the carriageway have to be soundproofed. Along other roads housing construction is not permitted within thirteen meters from the edge of the carriageway.

But the most noteworthy examples of protection against traffic noise in new towns are in Great Britain. In Stevenage, for example, a new town of some 100,000 inhabitants, road traffic, cyclists and pedestrians are entirely segregated. Transit traffic has to take a circular route and traffic to the town itself ends up in parking lots outside the housing estates. Cycle and footpaths are the only routes passing through the residential areas. Thus, apart from increased safety and a better environment for play and for walking, traffic noise is considerably reduced. Motor traffic is being prohibited on an increasing scale in some of the older quarters of towns throughout Europe. In Rouen, France, two streets in the center have been closed to vehicles and a broad pedestrian precinct is planned. Vehicle-free zones have been set up in Norwich in Great Britain, Copenhagen in Denmark, Essen in Germany, Bern in Switzerland, Vienna in Austria, and elsewhere. Other towns will be introducing the same restrictions. (5-20)

In Switzerland, a dozen streets in Zurich are closed to mopeds and motorcycles between 10:00 p.m. and 7:00 a.m. in order to protect the local hospitals and residential areas from noise, and since 1959 vehicles passing through Lausanne have had to go around the city during the night-time. It is important to mention here that heavy vehicles are not allowed to run anywhere in the country during the night with the exception of buses, fire engines and trucks carrying certain perishable goods. Also, in the Federal Capital of Switzerland, the public decided not to spend money on buses but to extend the trolley-bus routes which cause less pollution and noise. This has influenced other Swiss cities to do the same thing. Bern thus provides a perfect example of a combination of traffic noise abatement--a ban on trucks, vehicle-free zones and near-silent public transport. (5-20)

5.3 Railroad and Rapid Transit

5.3.1 Railroad

Railways were originally supposed to involve far less of a noise problem than roads and airports. However, this view is beginning to change, especially with the introduction of high speed trains. More countries are paying attention to this problem. Some countries have already introduced legal measures to control noise from trains.

5.3.1.1 Regulations

Environmental quality standards concerning noise from the Shinkansen Railway in Japan have been established. Noise standards for this type of super-express train were issued by the Environmental Agency of Japan on 29 July 1975. According to the Ministerial order, the regulation level for Area I (mainly residential areas) is 70 dBA and for Area II (commercial and industrial areas) 75 dBA. It also shows the target fulfillment period. These levels have been established from the results of a survey on community response to noise. As for ordinary train noise, there is at present no statutory control in Japan. (5-22) (5-23)

5.3.1.2 Guidelines

The Japanese train noise standards have been set at 70 dBA or below in areas used primarily for residential purposes and at 75 dBA or below in other areas which should be still similarly protected from noise pollution in the residents' daily lives. These standards must be attained as soon as new railroads have been constructed and put into service. In the case of existing railroads they must be achieved with the least practical delay. (5-22) These standards have been adopted by the Tokyo Metropolitan Government 1974 Plan to Protect Citizens of Tokyo from Environmental Pollution.

Compliance with these standards is determined as follows: "Train noise shall be measured at points one meter from each residential structure and this should be done with respect to trains that pass through the spot in one hour. The maximum noise level is recorded for each train, then the arithmetic mean taken from the higher half of the maximum noise levels thus recorded shall be the representative value for checking the compliance. The measuring device to be used shall be either the sound level meter specified in JIS C1502 of Japan Industrial Standards or the precision level meter in International Electrotechnical Commission (IEC) publication 179" (5-22)

5.3.1.3 Non-Regulatory Actions

Noise from railroads is being attacked in various ways in the Federal Republic of Germany. The first project is to design cars and engines which do not produce much noise. Additionally, there is a trend towards concrete bridges rather than steel bridges, and there is a nationwide program to polish the rails of the main connections at a rate of 5000 km per year (approximately 3100 miles/year), in order to get rid of the micro-ripples. The latter procedure reduces noise emission by an average of 5 dBA. The rail segments of the main connections are already welded together in order to reduce noise and vibration. (5-23)

In the United Kingdom, the following tables relating to reduction in noise level caused by a railway cutting and reduction in noise levels due to houses have been provided by a recent investigation.

Table 5-19 Reduction in Noise Level in dBA Caused by a Railway Cutting at Two Distances from the Track.

		Reduction in Noise level (dB(A))					
Cut depth difference (m) (re:1m)		2		3		5	
Distance (m)		Near Track	Far Track	Near Track	Far Track	Near Track	Far Track
25	Mean (S.D.)	2.67 (0.52)	2.33 (0.82)	3.67 (0.82)	2.83 (0.75)	5.67 (1.75)	5.33 (1.21)
40	Mean (S.D.)	3.00 (0.89)	1.3 (-)	3.67 (0.82)	1.3 (-)	4.67 (1.86)	3.0 (-)

Source (5-26)

Table 5-20 Summary of Reduction in Noise Levels Due to Houses

Type of House	Det/S.D.	Terraces approx. 150m long		Terraces approx. 300m long	
Number of rows	1	≥2		1	≥2
Number of sites	3	7	(6)*	11	7
Number of trains	12	30	(24)	28	16
Excess attenuation dB(A)	8.3	11.9	(12.9)	14.7	17.1
Standard Deviation (dB)	1.84	3.06	(1.69)	2.7	2.2

*Omits data for reduction at one site that was much less than expected compared to the other sites.

Note: (1) Gap in terrace can reduce effect by 3dB(A) in region of gap (2) High banks reduce effect considerably (by about 4 or 5dB(A))and can effectively reduce the number of rows of houses (3) All train types appear to be affected in the same way.

Source: (5-26)

5.3.2 Rapid Transit

Subways constitute a critical element in the urban transportation system, while streetcars are vanishing from the scene. A section on surface traffic noise would not be complete without at least a brief review of noise control measures or activities aimed at reducing noise from subways.

Foreign subways, such as Toronto, Hamburg or Berlin, are reputed to be quieter than those in the United States. A brief review of examples of subway noise reduction may be of interest.

In Japan, a noise measurement survey was conducted through a test run of a subway train over a straight section of the Ginza line, and an acoustical treatment on the side walls and ceiling of the tunnel was employed for noise reduction purposes. The sound-absorbing material consisted of flannel, asbestos spray and mineral wool spray. It was found that the noise level in the car could be reduced by 5-8 dB over the entire frequency spectrum from 100-4000 HZ. (5-27)

In the design of the Toronto subway, noise control was an important consideration. The source of the subway noise, broadly speaking, is the subway car itself. In modern cars with properly designed suspensions, couplings and drive mechanisms, the principle remaining noise is that produced by the rolling contact of metal wheels on rails. The vibrations thus set up in wheels and rails are radiated directly as airborne noise within the subway enclosure and are greatly accentuated by tunnel reverberation. (5-30)

One of the factors contributing to noise on older subway lines is the series of impacts produced by open rail joints. The modern practice of welding rail joints has eliminated this problem. Experiments were undertaken on the Paris Metro to eliminate the metal-to-metal contact by using rubber tires. Airborne noise in the subway enclosure may be controlled by applying sound-absorbing material as close to the sound source as possible. In the Toronto subway, a 4-foot-wide strip of highly absorbent material was mounted along the tunnel walls at wheel level. Noise at various stations in the Moscow subway network was measured over a frequency range of 25 to 1600 Hz. Table 5-21 shows high and low readings for each octave band.

Center Frequency, Hz	Sound pressure level, dB	
100	Low: 78	High: 94
200	79	101
400	88	105
800	79	102
1600	82	98

Table 5-21 Noise Levels in the Moscow Subway. Source: (5-55)

Typical escalator and train operating compartment readings were 84 dB and 90 dBA. (5-33)

The construction of the Vienna subway, a twenty year project begun in 1969 and expected to open in 1980, will run through a vicinity of noise-sensitive areas where concert halls, the State Opera Building, hotels and residential buildings are located. Judith Lang, in a paper given during the Inter-Noise '76 Conference, described the noise control measures and their effectiveness in dealing with noise problems associated with the Vienna subway:

> "From sound level measurements carried out in buildings near the Viennese municipal rail system and from the results of measurements in different European cities as reported in the literature, it can be seen that the noise from underground trains passing by can usually be detected inside buildings as far as 20 m from the tunnels. The sound levels range from 50-70 dBA near the tunnel to 20-40 dBA at greater distances.

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Noise control measures, therefore, had to be found. In order to design these in a most effective and economic manner we had to gather the following data:

- the vibration levels of the subway structure
- the influence of different track support systems on it
- the attenuation in the ground
- a possible attenuation from the tunnel into the ground and from the ground into the building
- the propagation of the sound within the building.

The work on the design of sound insulation measures started in 1968 by order of the Viennese Transport and Municipal Legal Authorities." (5-32)

Data on vibration and the effect of sound absorption of airborne noise on the Vienna subway is provided in the following table and graphs.

track support system	sum of octaveband vibration levels 31,5, 63, 125 Hz								subsidence mm	
	concrete ground-plate				pile 7,5 m distance					
	a 1)		b 2)		a		b		a	b
	dB(A)	dB	dB(A)	dB	dB(A)	dB	dB(A)	dB	mm	mm
wooden sleepers on 20 cm ballast	58-62	83-86	56	81	45-48	76-78	44	69	2.0-2.2	2.1
wooden sleepers on 40 cm ballast	58	84	55	83	48	76	48	75	1.4	2.4
polyurethane sleepers in concrete	57	83			46	76			0.5	
polyurethane sleepers in concrete on rubber mat	55	81	60	85	44	74	46	77	1.1	1.2
polyurethane sleepers encased in rubber envelope in concrete	54	81			45	78			0.6	
polyurethane sleepers encased in rubber envelope in concrete on rubber mat	48	75			40	73			1.7	
polyurethane sleepers encased in rubber envelope in concrete on mineral wool slab	43	75	46	80	39	72	40	77	2.2	2.8
wooden sleepers encased in rubber envelope in concrete	55	82			45	79			0.3	
wooden sleepers encased in rubber envelope in concrete on mineral wool slab	46	76	46	79	36	69	38	75	2.3	2.6

1) After construction; Stadtbahn-train, speed 40 km/h.
2) Subway-train, speed 80 km/h.

Table 5-22 Low-frequency-vibration Levels Measured with Passing Train for Different Track Support Systems - Vienna Subway.

Source (5-32)

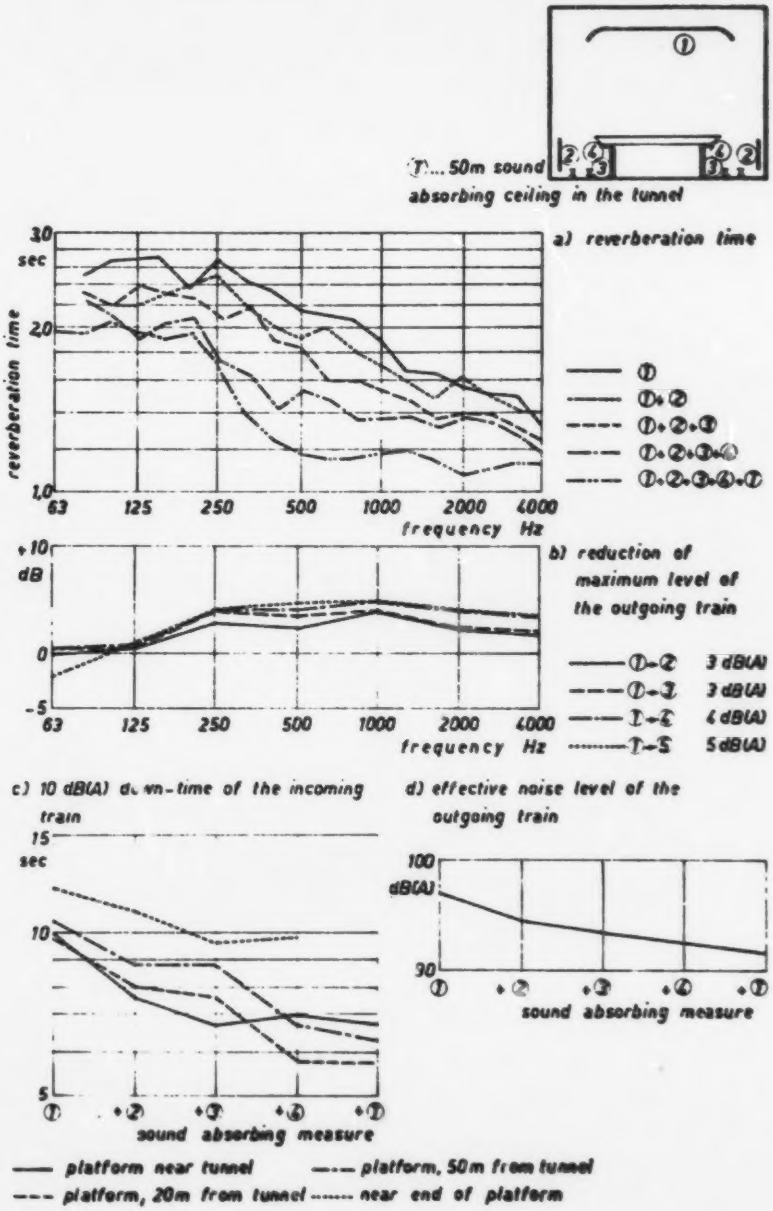

Figure 5-11. **Effect** of Sound Absorption to Reduce Airborne Noise in the Station.

Source: (5-32)

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6. NOISE INSIDE BUILDINGS

6.1 Introduction

The design and construction of buildings are governed by a wide range of laws, regulations and codes to ensure that new buildings meet basic requirements for safety, health and comfort. In recent years the responsibility for building regulations has, in most European countries, been extended to the national level, thus abandoning the practice of leaving the supervision to local authorities. In ECE countries attempts have been made to extend such regulations to the international level.

The first step toward an international building code was made in 1970. The Committee on Housing, Building and Planning requested its Working Party to undertake a comprehensive study of the existing building regulations in force in ECE countries. The first draft was prepared in January 1973 and has subsequently been revised and supplemented by additional data submitted by the governments and international organizations concerned. (6-4 p.1)

Altogether, twenty two ECE countries participated in the program, which resulted in the publication of "Building Regulations in ECE Countries" (New York, 1974). The compilation includes building regulations, official building authorities and other bodies concerned with the legislative framework of construction, the means of control and procedures for approval of buildings and building projects, and the scientific research pertaining thereto. The participating countries include Austria, Belgium, Bulgaria, Cyprus, Czechoslovakia, Denmark, Finland, France, FRG, Ireland, Italy, The Netherlands, Norway, Poland, Romania, Spain, Sweden, Switzerland, United Kingdom, U.S.A., U.S.S.R., Yugoslavia.

Among other measures promoting a better cooperation among ECE countries, one in particular deserved attention. At the Fourth ECE Seminar on the Building Industry, held in London in October 1973, agreement was reached on a series of measures to be taken on the national and international levels to remove technical obstacles to international trade in the building field. (6-4 p. 4)

6.2 Decision Criteria For Noise

Fifteen large-capacity office rooms in Switzerland were investigated for noise levels; 591 employees were interviewed, mostly males between 20 and 40. Noise was measured in several spots more than once. The noise level prevailing 50 percent of the time and fluctuating between 47 and 52 dBA was designated as mean level and set at L50. At this level, there was no interference with intelligibility of speech. Noise values that exceeded the acceptable level by 1 percent of the time were designated as frequent peaks L_1. This boundary value ranged from 57 to 65 dBA. (6-1 p. 274)

Employees interviewed on their reactions to noise in fifteeen office rooms have generally complained about excessive noise levels despite the fact that the measurements showed that noise levels were relatively low. Altogether 35 percent, mainly managers and college graduates, declared that they felt annoyed by noise. (6-1 p 275) Percentage-wise, the sources of annoyance were pointed out as follows: 45%, conversation; 25%, office machinery; 20%, telephone; 8%, loafers around the office; 2%, outdoor noise.

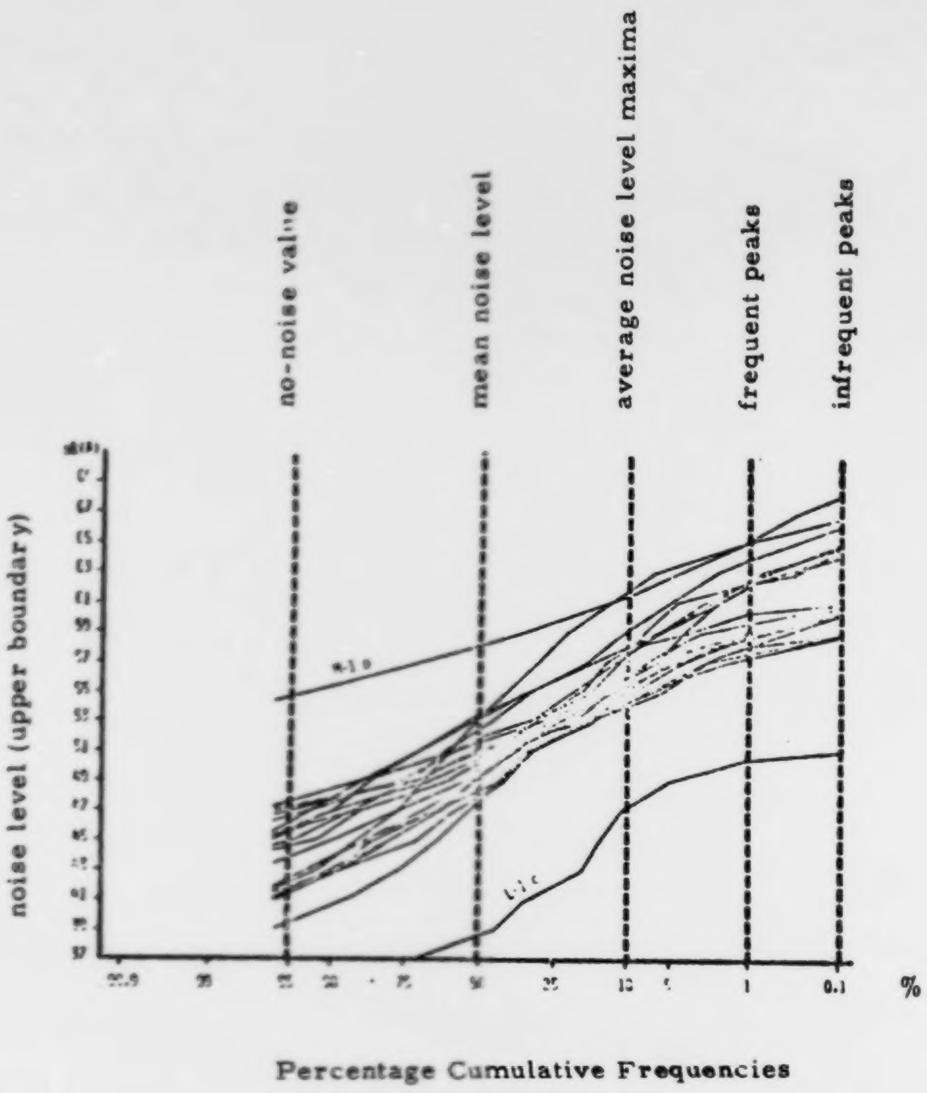

Figure 6-1

Cumulative Frequency Curves of Noise Level in 15 Large-capacity Office Rooms
Source: (6-1 p 274)

Interviews conducted with the employees of the fifteen large-capacity offices have proven that large offices have better acoustic qualities than small offices with the same amount of employees per specific area (6-1 p 278) since in a larger room the noise distribution patterns is more uniform than in a smaller room (although the mean noise level L_{50} was found to be almost equal in both types of offices).

6.3 Regulations and Guidelines

6.3.1 General

Building regulations in ECE countries are valid for all types of building activity and all types of buildings and structures.

In most countries, there is a difference between building regulations and technical standards. Standards usually state dimensions and properties of material, whereas building regulations refer mainly to requirements such as structural safety, fire security, indoor climate, sound insulation, etc. Above all, building regulations state that a building permit must be obtained before a building is constructed, the basic aim being to ensure health and safety.

It is possible to discern a certain general structure in the system of building regulations in most ECE countries. This structure usually consists of building laws, regulations supplementary to the law, and finally regulatory documents also comprising technical specifications.

In the USA, FRG, or Switzerland, there are as yet no regulations that are mandatory for the whole country, although basic construction regulations have, as a rule, a nationwide validity.

At the national conference on noise abatement in Varna, a paper was delivered on low-noise machinery operating inside residential buildings in East Germany. (6 - 8) According to the existing regulations in force in East Germany (Landeskulturgesetz), the maximum permissible noise in dwellings is set at 40 dB by day and 30 dB by night. This makes it imperative to limit the noise level of machinery such as elevators, ventilators, water-pressure raising facilities, etc. in multi-story residential houses.

6.3.2 Australia

The Australian Environment Council (AEC) recently (1975) commissioned studies on the noise levels of household appliances consequently, standards are expected to be issued some time in 1976 following the availability of results from the above studies and tests. (6 - 11)

The recently published Australian Draft Standard DR75136 for "Ambient sound levels for areas of occupancy within buildings" is evidently not yet in force. (6 - 18)

The Department of Environment and Conservation of South Australia plans to introduce a Noise Control Act (presumably in 1976) which would establish acceptable noise levels and noise specifications for domestic noise sources such as air conditioners, lawn mowers, swimming pool pumps, filters, etc. (6-12)

6.3.3 Netherlands

In the last two years (1974 and 1975) the Department of Public Health and Environmental Protection (Volksgezondheid en Milieuhygiene) of the Netherlands has carried out a preliminary noise abatement program, which was formulated in 1972, and which included a section on town building. In 1976 the proposed Noise Abatement Bill will be debated in the Dutch Parliament, discussing the problem of new regulations, a better application of existing regulations and the avoidance of new noise problems when planning and designing industrial facilties, houses and roads.

In the Netherlands, the design standard for noise insulation in dwellings (NEN-1070) dates back to 1962. The present study aims at updating and expanding the text. (Measuring methods employed are in agreement with ISO/R 140-1960. The assessment-procedures laid down in NEN-1070, however, are different from those in ISO/R 717-1968.)

In the Netherlands, the only existing legal regulations in the field of noise inside buildings are to be found in the municipal by-law regarding building. They consist of building codes, partially derived from NEN 1070. However, these codes are hardly supplied and there is no enforcement or performance testing at all. Thus in the Netherlands, with its large building programs after World War II, a large number of houses is known to have insufficient noise insulation with respect to adjacent houses. The booming developments in hi-fi and other electro-acoustical equipment have led to a serious noise problem, the appearance of which was triggered in particular when the Noise Abatement Bill was presented to Parliament.

The Bill contains under Section 17 an Amendment of the Housing Act, which will make it possible for the Ministers of Housing and of Public Health and Environmental Protection together to set noise standards for new houses and to introduce a compulsory performance testing system for housing designs and finished buildings. (6 - 13)

At present some pilot projects are undertaken to apply existing know-how to new housing projects and to existing houses (renovation and rehabilitation) in connection with other improvements.

In some Dutch cities, municipal building authorites took the initiative to set up noise insulation programs in close cooperation with the building industry (Middelburg) or to use their authority to get better results from building participants (Eindhoven).

For noise sensitive buildings no legal actions have been taken so far. However, these are foreseen in the Noise Abatement Bill.

In the construction of these types of buildings, usually attention is being paid to the noise aspects and acoustical consultants are frequently involved.

For 1976 more insulation projects are foreseen in the Netherlands and it is expected that with the new NEN-1070 in force, as well as a new directive of the Minister for Housing with regard to subsidized housing, the projects will ensure housing will have better insulation. The implementation problems for the building industry will necessitate a gradual introduction of the new regulations.

Consumer organizations in the Netherlands have been very active over the past three years with the noise problems of home appliances and show test results in their comparative consumer reports in addition to surveys of traffic noise and building noise problems.

The Government is preparing public awareness campaigns with respect to the use of less noisy equipment for household and hobby purposes. In 1976 a major campaign is foreseen in this field. The Noise Abatement Bill includes sections on standards and labeling of such appliances.

6.3.4 Belgium

In Belgium, there is one general noise pollution law, dated July 18, 1973. This law empowers the King to take the necessary measures for controlling noise including the prohibition of production or sale of high-noise machinery and imposition of standards for noise reduction devices. (6 - 15 p. 9)

6.3.5 Sweden

In Sweden, noise inside buildings is handled by the National Board of Urban Planning, in cooperation with the National Board of Health and Welfare, both in Stockholm. Noise from household appliances and lawn care equipment is handled by the National Board for Consumer Policies. (6 - 16)

6.3.6 Denmark

In Denmark, within the last two years (1974 and 1975), the standard for sound insulation in buildings ISO/R 140 has been revised. The finalized test should appear in 1976, together with the revised ISO/R 717. In 1976, work is planned on a standardized procedure for the measurement of sound insulation of suspended ceilings. (6-17) Noise inside buildings is regulated by the building regulation (Bygnings-reglement) of 1972, but there are no programs on household appliances and law care equipment. Such programs are presently under study by the EEC commission on noise.

6.3.7 West Germany

There are no national regulations in FRG (as of January 1976) on noise originating inside the building, but there are guidelines issued by the DIN and VDI, dealing with noise from the heating system, household appliances, elevators, air conditioners, etc. (6 - 19 p. 9) The DIN 4109, the most important guideline, deals with insulation against noise effects inside the building. These recommendations have been incorporated in laws of some of the German states (Laender). As a rule, hospitals and schools must get improved sound insulation during construction. Some DIN and VDI recommendations refer the sound insulation of the outer walls of buildings and their windows.

Filter measurements of airborne and impact noise of structural parts are done according to frequency, as stated in DIN 52210 (Nos. 1, 3 and 4), issued as a draft between January 1971 and December 1974. They are generally in agreement with the ISO recommendation ISO/R717 (1968). The finalized version was expected to be put in force some time after April 30, 1975, the deadline for comments on the proposed standards.

The Council of Experts for Environment Problems (Ref. 6.23, p. xi) in FRG recommended a stricter control over residential construction with respect to noise abatement, as well as general lowering of noise limits inside dwellings. Table 6-1 (6-23 p 80) lists the mean and maximal noise levels in dBA, according to the existing VDI guidelines (VDI Richtlinie 2729), for dwellings.

Table 6-1
German Interior Noise Criteria (Guideline)

Type of Room	Mean Level in dBA	Mean Maximal Level in dBA
Bedrooms	25-30	35-40
1) in residential/hospital/ recreational areas	25-30	40-45
2) in other areas	30-35	40-45
Living rooms		
1) in residential/hospital/ recreational areas	30-35	40-45
2) in other areas	35-40	45-50

Source: (6-22 p 153)

The guidelines for assessing noise in apartments, according to the existing West German norms (as of December 1974) are presented in Table 6-2.

Table 6-2
West German Norms Related to Noise in Residences

Norm* and year	Maximum A Noise Level in dB	Mean Level (a criterion for assessment) in dB
VDI 2058 - 1973	35	25
VDI 2565 - 1971	30	--
VDI 2569 - 1972	40-45	30-40
VDI 2719 - 1973	35-40	25-30
DIN 4109 - 1962	30	--
TA noise - 1968	--	30
ISO R 1996- 1971	--	25

* VDI 2058 - assessment of working noise; VDI 2565 - assessment of of noise inside apartments; VDI 2569 - assessment of traffic noise; VDI 2719 - noise attenuation by windows; DIN 4109 - noise protection in construction of buildings; TA law (see section on West Germany); ISO R 1996 - assessment of noise with respect to community reaction.

A draft of a norm for measuring airborne sound insulation outer walls and windows, to be commented on until April 30, 1975, is given in DIN 52210 (Dec. '74).

Certain design characteristics of walls, partition, and ceilings could reduce the noise level by about 10 dB. (6-20 p. 46) Walls partitions between apartments should be about 350 to 500 kg/m^2 in thickness and should have an additional noise-attenuating skin of 40 mm thick mineral wool plus a 12.5 mm gypsium cardboard plastering. Ceilings between apartments should be 350 to 500 kg/m^2 with "floating" floor finish on a 20 mm fiberboard.

Flanking (facade) outer walls should have a minimum weight of 350 kg/m^2 with a noise-attenuating skin of 80 mm mineral wool and 12.5 mm gypsium cardboard plaster. Additional modifications are available. (6-21 p. 129)

As far as household appliances and lawn mowers are concerned, there are no national noise emission limits in FRG. The EEC commission on noise is currently (Jan. '76) working on establishing uniform noise limits for these types of machinery. (6 - 19 p. 9) With respect to lawn mowers, there is a variety of local regulations, usually calling for night-time, noon, and Sunday curfews.

6.3.8 United Kingdom

There are a great number of standards in the United Kingdom relating to the design of structures to achieve various acoustical properties of transmission loss and absorption in addition to specialized recommendations for hospitals and schools. Recently there has been an increasing usage of ISO practices and no doubt EEC will produce its own standards, particularly if the recommendations listed in the following document are accepted (H. Bastenier,

W. Klosterkoetter and J. B. Large "Damage and annoyance caused by noise" EEC Eur. 5398e. 1975).

Interior noise in the United Kingdom is usually measured in terms of peak dBA. But it is usual to specify an exterior environment with the inference that the indoor noise levels will then be acceptable. For example, an NNI of 35 is usually considered an acceptable external environment, whereas an NNI of 55 requires the application of soundproofing.

The Building Research Establishment in the United Kingdom carried out research to ascertain what acoustic, thermal, and ventilation specifications were required to insure that proper interior noise environments could be attained. Much of this work had previously been completed in solving the Heathrow Airport noise problem. In their studies, the BRE evaluated structural mass requirements, enclosure continuity, and optimum wall structures with special consideration of double leaf constructions. As a result of this research a noise insulation implementation package was developed. (6 - 9)

The specific requirements of the insulation package appear in the Noise Insulation Regulations. Applying only to eligible buildings, the insulation package consists of:

1. Replacement or conversion of existing single pane windows. For a given pane thickness the regulations specify the air space between the windows. This is to assure adequate transmission loss. All gaps are required to be sealed with compressible resiliant strips. Also, it is required that both windows must be openable for direct ventilation and cleaning.

2. For control of solar heat the insulation package requires that venetian blinds be fitted between the panes of the double windows. The blinds must be white or near white with a slot width to spacing ratio of between 1.15:1 and 1.25:1.

3. For control of ventilation, the package includes a noise attenuating ventilator incorporating a variable speed fan. The regulation specifies that the ventilation rates must range from at least 37 liters per second (l/s) at a back pressure of 10 Newtons/square meter to 10 l/s. at zero back pressure.

   At its maximum ventilation rate, the unit must have a noise output of less than 40 dBA. At the rate of 31 L/s. with 10 N/m^2 back pressure, the sound level must be less than 31 dBA. In these determinations the measured noise levels must be adjusted to account for room absorption by subtracting a term involving $\mathrm{Log}_{10}A$, where A is the measured room absorption.

   So that transmission of noises from the exterior through the ventilator unit into the room may be minimized, the regulations specify minimum 1/3 octave transmission loss figures from 10 Hz (30 dB) to 3150 Hz (53 dB).

4. The regulations also call for a permanent vent to be installed in each eligible room. The vent must be of the sound attenuating type with the same transmission loss shown in Table III. Minimum and maximum effective air path areas are also specified.

6.3.9 Japan

Japanese law, article 22-2, item 2, no. 1, states that a sound-insulating wall should have a planar density of over 110 kg/sq m. Double-wall structures should be at least 35 mm thick at the intermediate air seam and have more than 60 kg/sq m total planar density. Table 6-3 shows transmission losses of a sound insulating wall, according to the new amended standard in force since 1971 (6-2) and (6 - 6)

Table 6-3

Minimum Transmission Losses of 'Sound Insulation' Wall according to Japanese Law

Octave Band (Hz)	Transmission Loss (dB)
125	25
500	40
2000	50

Source: (6-2), (6-6)

The level of transmission loss in windows is found by measuring the difference between average acoustic levels for two rooms with an intermediate window. (6-2)

The level of transmission loss in windows due to the sash was defined as above 18 dB in 1970 (in Japan) when the KJ-11-type aluminum sash was authorized. In 1972 a sound-insulating sash with more than 25 dB level of transmission loss even after 10,000 times of opening and closing was designed. (6-2)

Modern soundproof walls for traffic and factory noises (in Japan) are both sound-insulating and sound-absorbing (Ref. 6.2).

Table 6-4 shows the boundary values for airborne noise and impact noise insulation (A: minimum requirements; B: desirable requirements) applicable to Switzerland.

Table 6-4

The Boundary Values for Airborne Noise and Impact Noise Insulation Applicable in Switzerland

	Airborne Noise Insulation Index I_a (dB)		Impact Noise Insulation Index I; (dB)	
	A*	B*	A	B
School Premises (EMPA guidelines)				
1. Partition walls between classrooms	45	55	--	--
2. Partition walls between classrooms and corridors	35	45	--	--
3. Ceilings between classrooms	50	55	65	55
4. Partition walls and ceilings between music rooms (classes in singing) and adjacent rooms	--	55	55	45
5. Partition walls and ceilings between music training rooms	--	55	55	45
Hotel Rooms (EMPA guidelines)				
1. Partition walls and ceilings between guest rooms	50	55	65	55
2. Partition walls between guest rooms and corridors	45	50	--	--
3. Partition walls and ceilings between guest rooms and restaurant, kitchen, etc. premises	55	60	55	45
4. Insulation between guest rooms and bowling alleys	55	65	25	25

* A: Minimum Requirements
B: Desirable Requirements

Table 6-4
(Continued)

	Airborne Noise Insulation Index I_a (dB)		Impact Noise Insulation Index I_i (dB)	
	A	B	A	B
Dwellings (SIA recommendations)				
1. Wall partitions, staircase walls, ceiling partitions	50	55	65	55
2. Arcade	--	--	65	55
3. Partition walls and ceilings between flats and businesses, such as workshops, restaurants, etc.	60	65	50	45
4. Apartment and house doors				
a) opening inwardly	20	25	--	--
b) opening outwardly	--	25	--	--
5. Windows and glass doors	20	30	--	--
Business Premises (EMPA guidelines)				
1. Partition walls and ceilings between various enterprises	45	55	65	55
2. Partition walls and ceilings between premises of the same enterprise	35	45	65	55
3. Partition walls and ceilings between premises with machinery and office rooms	55	60	50	45
4. Partition walls and ceilings of manager's rooms, conference rooms, etc.	45	55	65	55

Table 6-4 (Continued)

	Airborne Noise Insulation Index I_a (dB)		Impact Noise Insulation Index I_i (dB)	
	A	B	A	B
Hospital Rooms (EMPA guidelines)				
1. Partition walls and ceilings between sick rooms	45	55	65	55
2. Partition walls between sick rooms and corridors	45	50	--	--
3. Partition walls between sick rooms and rooms such as kitchens, offices, etc.	55	60	55	45

Source: (6-3)

6.4 Building Insulation Against Traffic Noise

The placement of houses and buildings on sites near traffic routes and highways introduced a major environmental annoyance problem caused by the continuous flow of traffic. This problem was severely experienced especially in areas where preplanning or zoning was never made. To reduce noise levels to compatible limits inside houses and buildings, some countries took different measures to insulate from traffic noise. Sound absorbing materials have been used for building noise control in several ways. Experimental sites have been constructed to develop the most effective means and guidelines to deal with this problem. However, it is fair to say that insulation of buildings is considered to be the least desirable measure in fighting noise due to its costs and also due to the fact that it has no effect on external noise levels in such areas as private and public open space.

In the United Kingdom the DOE Building Research Establishment (BRE), besides achieving the mentioned noise insulation implementation package, has been engaged in other noise insulation experiments. A pilot noise insulation project has been carried out on a flat 30 meters from the edge of a motorway in Douglas House apartments adjacent to the Midland section of the M6 motorway near Birmingham. Behrens and Barry in their report "European Experience in the Highway Noise" describe the experiment and its results as follows:

> "This experiment was carried out to study the attenuation effects of sound insulating a dwelling from heavy traffic noise 82± dB(A) and to develop and evaluate special ventilation and solar heat gain control methods. Insulation treatment on the living room and bedroom consisted of installing double windows with white venetian blinds between the window panges, a double french door leading to a patio, and a sound insulated mechanical ventilation system. Existing windows were fitted internally with additional glass panes spaced 20 mm from the existing panes, and white venetian blinds,

> operable from within the rooms, were fitted within the sound absorbing, fiber lined cavity to assist in solar heat control. Means of ventilation were provided by a ventilator fan unit which drew air into the rooms and a separate permanent vent which reduced high back pressures, installed on external walls.
>
> This experiment was carried out concurrently with England's preparation of specifications covering sound insulating, ventilating and solar heat gain control measures to be taken in dwellings qualifying for treatment under their 1973 (Building and Buildings) Noise Insulation Regulations, and provided the basis for insulation measures presently being employed under these regulations.
>
> The overall measured sound reduction, outside to inside, was 35 dB(A), compared with 10-15 dB(A) for the original windows partly opened for ventilation. External noise levels of about 80 dB(A) were reduced to approximately 47 dBA. (6-24)

When writing about noise insulation in Sweden the authors of the mentioned report state that:

> "Generally local city planning and zoning regulations and related building codes would require builders of new homes, apartment buildings, offices, etc. to insulate for traffic noise as well as for heat if a traffic noise impact existed or was anticipated. In cases involving traffic noise impacts on existing buildings, either due to existing or anticipated traffic as a result of new highway construction, the local governments were obligated to take the necessary remedial noise abatement measures which could include noise insulation work.
>
> Such noise insulation work normally consisted of installing special openable, window units. One common type of special window unit used had three window panes; 2 panes about 3 cm. apart to act as thermopanes for heat insulation and a third pane 8-10 cm. apart for sound insulation. Ventilation systems were provided if needed, in multiple residential buildings (apartments, etc.) and office buildings. Such systems were certified to meet adopted air circulation standards.

> To assist in the determination as to whether traffic and other existing noise warranted special noise insulation consideration, the City of Stockholm had prepared a map (completed in 1973) which indicated the noise situation for the entire Stockholm area. Map preparation involved the measurement of existing noise at about 250 different sites around the city between 1968 to 1973. This noise data was supplemented by noise prediction modeling calculations to obtain noise information for map areas not measured. All major streets on the map had been color coded into the following five daytime noise impact catagories: 75 dBA, 70-75 dBA, 65-70 dBA, 60-65 dBA and 60 dBA.
>
> From this map, which is updated periodically, it is possible to judge what necessary noise impact precautions would have to be taken to fulfill interior noise requirements. Only where noise levels were below 60 dBA would ordinary window construction and planning of homes be possible. For levels up to 70 dBA, noise reducing windows would be necessary along with requirements concerning the orientation of rooms in the dwelling buildings and the orientation and design of the buildings themselves. For levels above 70 dBA, additional precautions would be needed such as exterior abatement measures, traffic or vehicle restrictions etc." (6-25)

No traffic noise insulation has been carried out in France and there seems to be no immediate plans to do any. Also there has not been any building insulation carried out for the specific purpose of reducing traffic noise impact in Switzerland. Noise insulation measures have been carried out in at least two places in Germany. Windows above three meters in residential dwellings 40-50 meters off a highway were insulated for traffic noise in Hannover and in the city of Munich. The Noise Group of the Federal Institute of Road Affairs has been conducting research on special window units which are claimed to achieve 30 dBA reduction of outside traffic noise level. This system involved an integral glazing-ventilation unit. Built into each double window unit is a small ventilator fan with a sufficient rate to meet room air change requirements. A diagram of this window unit appears below.

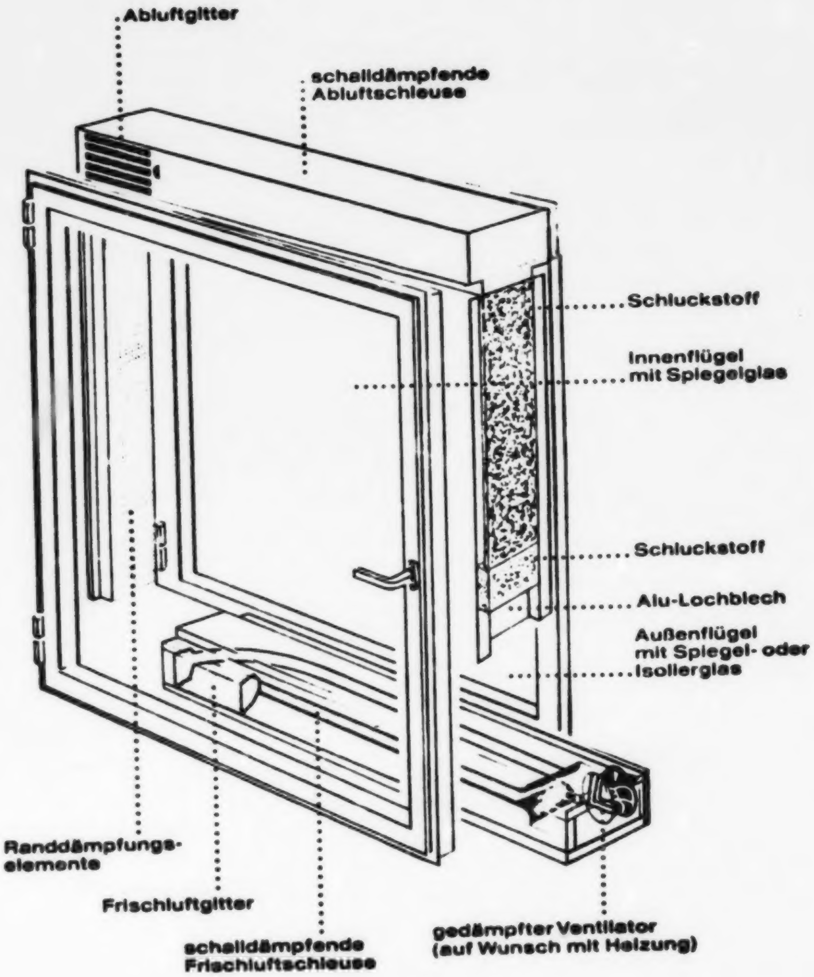
Abluftgitter
schalldämpfende Abluftschleuse
Schluckstoff
Innenflügel mit Spiegelglas
Schluckstoff
Alu-Lochblech
Außenflügel mit Spiegel- oder Isolierglas
Randdämpfungs-elemente
Frischluftgitter
schalldämpfende Frischluftschleuse
gedämpfter Ventilator (auf Wunsch mit Heizung)

Figure 6-2

Integral Window Glazing - Ventilation Unit Being Investigated in Germany

Source: (6-24 p 676)

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7. INDUSTRIAL AND CONSTRUCTION NOISE EFFECTS ON THE COMMUNITY

7.1 Introduction

Generally, noise from industry (including construction projects) has not been the most annoying source of nuisance in foreign experience; that honor is reserved for airports (where the annoyance experienced by a small number of victims has been more intense) and for vehicular traffic (a far more pervasive noise source) (7-20). This continues the ranking that was born out by earlier data such as the incidence of complaints in Germany (7-1); Japan, where noise around aircraft has been a particular problem (7-2); and the United Kingdom, where noise from factories was fourth-ranked (19% of those surveyed) and construction noise sixth-ranked (5%) in the Wilson Report.

While neither factories nor construction projects are major sources of annoyance, a given level of construction noise is more annoying than an equal level of traffic noise, according to recent studies (7-18).

7.2. Noise from Factories

7.2.1 Decision Criteria

Because industrial noise emissions to the community is basically a problem of nuisance and a quality-of-life issue, a fundamental difficulty is the psychological aspects of the problem: what kind and level of duration of sound from industry should be considered as undesirable when it intrudes into various kinds of surroundings?

It should not be thought that only heavy industry is responsible; light service industries scattered throughout urban regions contribute their share of noise annoyance, especially steam laundries, and reports on light industrial noise problems have been received from countries as varied as the U.K., Israel (7-12), and the USSR.

In 1973, the Verein Deutscher Ingeniere proposed that the rating of industrial noise in the community be determined from the loudness and duration of the noise. By altering the method of measurement, account was taken of noise containing bothersome tones or impulses and/or occurring at certain times of the day (7-3).

Here national differences in culture and life style become crucial. For example, it is easy to see the impossibility of determining one measure of industrial disturbance that would be adequate both for the Scandinavians, whose buildings are usually fitted with double glazed windows for protection against the severe climate, and the Israelis, who have an "open window" life style. Or as another example, one might consider the difference between some parts of Paris, where a certain amount of evening noise is said to be considered desirable for the ambiance (7-4), and Zurich, where quiet is highly valued and municipal ordinances against excessive noise are strictly enforced. The European Economic Commission (EEC) is now in the process of proposing noise guidelines dealing with annoyance, sleep, and speech interference which will be applicable to all member states. Similar work being carried out by the World Health Organization may result in a set of internationally acceptable environmental noise criteria (7-5).

Several factors are important in preventing noise annoyance:

a. Prevention of complaints. The British system based on BS 4142, for example, uses a standard measurement to predict complaints, which is highly useful for design and planning and also as a standard for determining whether a given complaint is reasonable.

b. Existing land use adjacent to the factory or construction site. The German concept is (Ortsüblichkeit)--"suitability to the locale". The British consider that noises 10 dBA above the local background level are likely to cause complaints, and if the noise contains unusual frequency distributions, such as shrill or pure tones, 5 dBA above background level will suffice (BS 4142).* The same concept enters the Swiss system in the assignment of appropriate noise climates for various zones of land use, to which is added maximum additional emissions desirable from sources like industry or construction.

c. Technical feasibility. Of course, what this really means is the question of how much can be done while holding costs to a given level, because nearly any degree of abatement is possible if one is ready to pay for it. A typical scheme for dealing with this problem envisages standards that would be reviewed periodically and were applicable on all units. One expert has alternatively proposed a standard whose language would stipulate that the noise level emitted by X% of a class of machines would constitute the standard. As more and more of the older existing equipment is replaced with new "noise-treated" equipment, the standard would have a built-in tendency to become stricter (7-7).

A major economic consideration in international noise control policies is the development of industrial policies which are less polluting, but which, at the same time, make full use of present technology. The integration of new methods of pollution control will inevitably impose cost burdens on firms and may contribute to slow rates of increase in Gross National Product. The initial costs of investment in industrial noise pollution control will be high, but once prescribed standards have been reached, only additional units of output will require incremental investment. Among European Economic Commission (Common Market) countries, only Denmark has referred to the costs of implementing anti-pollution measures in its noise legislation, but since 1974 the OECD has undertaken econometric studies of the impact of pollution control policies (7-8).

A useful tool for planning is a method by which the noise nuisance of a proposed new industrial installation can be estimated in terms of probability of complaints. The British have developed such a tool in British Standard 4142. Two of the men who have been most active in developing and using this standard, R. J. Stephenson and G. H. Vulkan, describe the way in which it is used:

> "This method calls for the establishment of a criterion for the area in which the factory is, or will be, situated, and then determining whether the noise or estimated noise from the factory will comply with this criterion, after having been corrected according to the circumstances.
>
> "The basic criterion of 50 dBA is first corrected, if necessary, by the addition of 5 or 10 dBA depending on the degree to which the particular factory fits into the character of the surrounding area and whether people are used to this type of factory. A further correction is then made for the type of area itself, ranging from minus 5 dBA for a rural area, to plus 20 dBA for a predominantly industrial area with few dwellings. If

> the factory will operate only on weekdays between 8 a.m. and 6 p.m., a further 5 dBA is added, and if at night-time 5 dBA are subtracted. The estimated noise from the factory, as heard outside the nearest dwelling or building where complaints are likely to arise, is also corrected for its tonal character, its impulsive character, if any, and for the intermittency and duration for which it will occur.
>
> "The two figures, that is, the corrected criterion and the estimated corrected noise level, are then compared. If the noise level is greater than the criterion by more than 10 dBA, complaints can be expected. If the two levels are within 5 dBA of each other, the position is marginal, and if the expected noise is 10 dBA less than the criterion, complaints would definitely not be expected. The above summary only gives an indication of the procedure and if this method of assessment is to be used it is, of course, necessary to refer to the Standard itself for the details " (7-8).

The development of this method dates back to the early 1960's and from the beginning was aimed at finding criteria that would not necessarily be the most desirable levels, but the levels which forstall complaints. Tests were made in over 60 cases including a number where complaints had previously been made; the method "gave a good prediction of the actual happenings in about 90% of the cases." The reader is referred to ISO Recommendation 1996 for the latest version of this approach, as the ISO Resolution is closely patterned on BS 4142. In British practice there are no fixed limits, but if calculations based on BS 4142 showed that a proposed site would probably bring noise nuisance complaints, permission to build would probably not be granted (7-8).

7.2.2 Industrial Noise - Regulations

In actual noise abatement practice, common methods are used everywhere which reduce themselves to two types: distance from the source at which abatement is applied, and control over the time when noise is created.

Distances range from inside the equipment itself (quieter engines and moving parts); outside but still part of the machinery (sound insulation layers, exhaust mufflers); near the machinery (complete enclosures or shields); in the case of factories, an intermediate distance (factory building construction, siting of installations inside the factory site); and finally, specifying the total distance between industrial noise sources and areas to be protected--the basis of the zoning concept--is another widespread noise control approach appropriate for factories.

Varying the time dimension of the noise emission, on the other hand, is a matter of either regulating operating hours or limiting total duration (for example, the total length of time a construction project may operate before it is considered a permanent rather than a "temporary" noise source.)

It may be expected that there will be a trend toward setting international standards limiting noise from certain machines like air compressors, blowers, ventilators. One source of impetus for this trend is similar to the OECD's motivation for setting standards for another kind of machinery, motor vehicles: the damage to international trade that would result if manufacturers were faced with a patchwork quilt of differing national limits that is likely to grow with time.

One aspect of factory noise regulation repeatedly stressed in the literature is the difficulty presented by the backlog of existing "noisy" factories that are prohibitively expensive to abate on the one hand, and too closely located to housing and other noise-sensitive areas on the other. "The most obvious way to diminish the risk of annoyance to residents by noise, fumes, or dirt from factories is at the town-planning stage, where residential and industrial zones can be separated" (7-8). But even if good noise planning was done on new industrial sites, the backlog of existing sites would remain. A basic policy of land-use planning worked out by the Greater London Council for noise nuisance prevention is concentration of all noisy sites in one area, on the principle that adding together two equal noise sources only causes a small increase in total noise level (3 dB), whereas one noisy site in a generally quiet area can set the noise climate for that entire area. The Soviets are also using this principle in Moscow by systematically moving certain noisy factories out of mixed residential areas in Moscow.

The Swedes have published guidelines for external noise emission on certain types of areas, particularly residential and recreational areas (7-13).

The subject of industrial noise nuisance prevention by zoning overlaps the more general subject of town-planning. Two sub-categories may be distinguished here in foreign practice: the slow improvement of an existing unsatisfactory pattern, and the easier case where a new industrial site may be shielded at the outset by requiring it to have a buffer zone. Working the former situation is expensive, as the following case study from Japan illustrates.

In 1969 more than 500 industrial firms were operating in the Chiba prefecture, and one of its six cities, Ichihara City, is considered to be the industrial center of the area.

The main industry operating in the area is iron and steel, electric power (4,200,000 kw) and oil refining (460,000 barrels per day). Pollution (noise, water, air) had been a major problem for Ichihara City.

To fight the pollution, Ichihara City passed city zoning laws in 1965 based on Basic Construction Law (National Law, Article 52). There were three categories of zones: 4,463 acres of industrial area along the reclaimed land; 5,079 acres of residential area; and 642 acres of neutral area. To further the zoning goals of Ichihara City, the Prefecture established in 1966 the "Construction Codes for the Chiba Prefecture Special Industrial Zone." The feature of the Codes is that they will prohibit construction of such public or private noise-sensitive institutions as schools, hospitals, workhouses, day nurseries, homes for the aged, residences, rooming houses, and hotels or inns in the area, and will oblige various parties to help in the financing of the project.

Based on national law, the "Government Work Agency for Pollution Prevention" (GWA) was set up as an administrative body designed especially for industrial pollution prevention. Its role is to achieve liaison between interested government and private institutions in a particular area to fight pollution. Its staff is composed almost entirely of government employees temporarily assigned to work on the local GWA.

The land utilization designated as "Special Industrial Zone" (SIZ) comprises an area of about 653 acres. A breakdown of the total area is given in Table 7-1.

Type of Land				Area (Acres)
I.	Public Land			
	A.	Green Belt		
		a.	Athletic Facilities	24.5
		b.	Seedbed	8.2
		c.	No. 1 Green Belt	53.9
		d.	No. 2 Green Belt	14.7
		e.	Green Belt for river bank and shore	6.5
		f.	Park	6.5
		g.	Green Belt roads	21.2
			Total	135.5
	B.	Streets		
		a.	Boulevard	33.5
		b.	Zoning streets	56.2
			Total	89.7
II.	Private Land			
	A.	Existing Residential		89.8
	B.	Warehouse		20.4
	C.	Driver's school		4.0
	D.	High voltage		21.2
	E.	Light Industry		277.7
	F.	River sites		14.5
			Total	427.6
			Total I. & II.	652.8

Table 7-1. Land Use in Special Industrial Zone, Chiba Prefecture Project

Source: 7-14

The budget for the Green Belt and Park in June 1966 was estimated at $6,722,222 (Y 2,186,000,000).

It is noteworthy that when polluting industries agreed to bear one-third of the total costs, they agreed under the condition that no increase in their burden would occur over a three-year period (1966-1969). A breakdown of the contributions of industries, Chiba Prefecture, and Ichihara City is given in Table 7-2.

Source of Financing				Amount
A.	1.	Electrical power industry	30%	$2,240,744
	2.	Oil refinery	21%	
	3.	Petrochemicals industry	22%	
	4.	Shipbuilding, iron & steel ind.	20%	
	5.	Others	7%	
			100%	
B.	Prefectural Government			$2,240,744
C.	Ichihara City			$2,240,744

Table 7-2. Financing of Chiba Anti-Pollution Projects.

Source: (7- 14)

The way each company was allocated their share of the total industrial one-third of total cost was based on: 1.) the number of employees in each firm; 2.) area of the factory; 3.) oil consumption; and 4.) value of annual production.

By the time the work started, the total cost had increased by 1.7 million dollars. Because of the condition caused by polluting industries, the prefecture and the city each bore a half of the increased cost, except that a very small amount was borne by new industries which moved into the area after the work was started.

Land purchase for Light Industrial Zones concerned land with existing residences located in the SIZ that had to be cleared and consolidated to make room for light industry. For 277.7 acres of Light Industrial Zones, a ten year plan (1966-1976) for acquisition and clearing has been in operation. The plan has been carried out by the Chiba Prefecture Development Foundation, totally financed by the prefectural government, and as of 1968, one third of the estimated 55.0 acres has already been purchased from private land owners by the Foundation.

Several problems have arisen in the course of the project. First, the city had a plan for another 20 m wide green belt between residential and special industrial areas. This green belt was not the one that the GWA planned. By law, the national government can only subsidize one-fourth of the total cost and the city must bear more than one-fourth of the cost in order for the city to get a national subsidy. The city doesn't have enough funds to implement this at the present time.

Second, residences existing in the special industrial zone before the plan was made still are a problem. At the present time, it is almost impossible to remove them because of the budget limitations. The governments of all levels and people are making practical solutions to the problem of existing residences, which are scattered in an area of about 90 acres.

Third, the heavy industries assumed their role reluctantly, and only in the end cooperated. During the initial period of negotiation, the industries complained about the size of their total contribution and also about the formula by which the contributions of individual firms would be calculated, i.e., number of employees, area occupied by the factory, quantity of oil consumed, and value of annual production. At that time the industries failed to come up with an alternative proposal for a formula, and the final compromise reached between government and industry was that one mentioned earlier: the industries would pay their share, but nothing toward any extra unbudgeted costs that might arise. This proved advantageous to them, as they did not have to pay any of the $1.7 million budget increase caused by inflation during the first three years of the project.

Despite all of the problems, Japanese national, prefectural and city governments and Japanese public opinion all praise the Chiba prefecture plan, which has been the first in Japan to carry out coordinated pollution prevention measures (7-14). They are hoping that such an example will inspire other cities, prefectures, airports, railroads, etc. to carry out similar plans. In fact, two other cities, Akaho City and Tokuyama City have already started similar projects for industrial zones with special green belts surrounding them. Their 1969 annual budgets together totalled about $690,000 (Y 215,000,000).

Efforts for noise abatement in areas where industry and housing are already mixed, such as the SIZ described in the Chiba Prefecture projects, are likely to give only partial success at best. This point can also be illustrated by another case pertaining to the Ruhr/Rhine area of Germany. Some success

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was achieved, but the conclusion was that noise emanating from large-scale plants such as iron and steel works "does, however, present an overall problem which in the long run can only be solved if all these measures are backed up by proper town and country planning" (7-1).

Japan and the Soviet Union have adopted strict zoning laws which specify noise levels for specific categories of districts. The Japanese enforcement standards for industrial noise emission in district categories are listed in Table 7.3. Consideration is given to noise emissions at three daily "time zones":

Table 7-4. Enforcement Standards for Industrial Noise Emission: Article 4-1, Noise Regulation Law.

Time Zone	1st category district	2nd category district	3rd category district	4th category district
Daytime	45 phon to less than 50 phon	50 phon to less than 60 phon	60 phon to less than 65 phon	65 phon to less than 70 phon
Morning evening	40 phon to less than 45 phon	45 phon to less than 50 phon	55 phon to less than 65 phon	60 phon to less than 70 phon
Night	40 phon to less than 45 phon	40 phon to less than 50 phon	50 phon to less than 55 phon	55 phon to less than 65 phon

Note; 1; Phon   Metric Law, Article 5, No.44
2; measurement; noise meter, JIS C1502, C1503, IESC Pub.179
instrument   Use A feature
3; Measurement method; provisionally, JIS Z 8731
4; 1st category district; good residential area, with special calm conservation efforts
2nd category district; residential area
3rd category district; residential use with commercial and industrial use. Noise control efforts are requested.
4th category district; mainly industrial use, but noise control efforts are requested.
5; District designation for 4 categories of districts should be done by prefectural governor.

Source: (7-15)

The Soviet Union has created "sanitary safety zones" around rural, suburban and urban areas. Noise levels in rural areas do not exceed 50 dBA during the day and 40 dBA at night. In urban areas, noise levels are 60 dBA and 50 dBA respectively, and in suburban areas the day/night variation is 45 dBA and 35 dBA (7-15).

The Soviet Union's Sanitary Norms of 1956 and 1963 require buffer zones of various widths up to 1000 meters in some cases, for 'dirty' industries whose emissions include gases and particulates. Furthermore, in siting such factories, it is required to take account of prevailing winds and locate the factory downwind of populated areas (7-16). These provisions almost automatically insure that these particular factories will not cause noise nuisance, and if the real estate is relatively inexpensive, the environmental protection costs will be relatively inexpensive. Furthermore, noise nuisance is being increasingly taken into account in deciding which factories require such zoning.

The Soviets have also begun to move light industrial enterprises located in Soviet apartment houses to specified industrial zones. In Riga, 50 enterprises were moved to industrial zones outside the city. If their industries are not relocated, plant officials are compelled to maintain strict compliance of noise norms. Public health officials in Riga have closed enterprises which emit noise above the norms (7-17).

There are no industrial zoning laws under the Dutch "Nuisance by-law", but firms are required to obtain permits granted by municipal authorities in order to begin operation. The authorities must take into account the potential "danger, damage, or hindrance to the neighboring community, which is caused by new industrial firms." Permission to operate may be withdrawn if the industrial establishment does not comply with the noise standards of ISO R1996 (7-5). Similar building permit procedures have been implemented in the West German "lander" of Boremen, Bader-Wurttemberg, Bavaria, Lower Saxony, and North Rhine areas (7-3). Article 16 of the Federal Republic of Germany's Industrial Code permits authorities to modify the premises or change the operating procedures of new industrial installations in order to enforce noise emission standards (7-5).

The Belgium noise law of 1973 permits the King to create protection zones corresponding to residential areas, industrial zones, recreational areas, and those areas where quiet is particularly required (7-5). This law has only been applied to the vicinity of motor racing tracks, but may subsequently be used in regulating the location of industrial establishments.

In the United Kingdom, local authorities may designate noise abatement zones according to registers kept of levels of noise emitted from premises within the zone (7-5). The control of noise from industry in London is the responsibility of the 32 Borough governments and upon complaint, are handled by public health inspectors. In most cases, action takes the form of "freindly discussions with offending firms and the giving of advice on methods of reducing noise." (7-18)

Australian state and regional planners have incorporated environmental and noise controls with development projects in the areas of industry and public works (7-5). As in the United Kingdom, Australian local authorities are empowered to control and regulate industrial premises for noise pollution.

As a final example, it may be possible to improve the sound insulation of the building if lighter construction techniques allow the replacement of load-bearing members with components combining both structural properties and sound-silencing properties at no additional cost in weight. For some time VDI guidelines in Germany (Richtlinie 2058 of 1960) had set out desirable goals for sound-insulation properties of industrial buildings. There was little problem in meeting desired attenuation of 40 dB (average for all frequencies) in the walls if they were constructed of heavy brickwork. But the minimum density of 100 kg per square meter requirement for silencing presented real problems in roofing construction, particularly where wide open spans inside the building were essential. German specialists therefore devised a roof design using plates of wall asbestos cement that reduced the density required to a more practical 37 kg per square meter, and even less if the sound insulation requirements were not so severe. An additional point of interest in this example is the way the Richtlinie, even though it was only a guideline, stimulated research toward a standard that might otherwise not have been achieved.

The Danish Environmental Protection Act of 1973 contains a clause concerning noise transmitted through building constructions, although it does not make recommendations as to how to improve the sound insulation of the building. Maximum levels of 30 dBA by day and early evening and 25 dBA at night are suggested (7-5).

The Greater London Council will use "zoning" within the industrial site in its construction of a series of government-owned industrial plants, including large scale incinerators, pulverizers, compactors, transfer stations, and other similar projects. In the course of its design work on refuse treatment plant, it has published design guidelines illustrating how a hypothetical plant might be planned (see Figure 7-1).

A number of abatement techniques are illustrated here. First, noisy processes are concentrated within a building with walls as imperforate as possible and with adequate acoustic insulation. Windows are minimal in area, on the side of the building away from noise-sensitive areas adjacent to the site only, and sealed. Second, noisy processes are located within the site in such a way as to minimize their emissions in a particular direction, in this case, in the direction of a hospital to the southeast. Other buildings act as shields, and one retaining wall and earth bank is provided to shield the noise from extensive activity by dump trucks coming and going.

The London refuse treatment plan (Figure 7-1) illustrates noise control through proper internal siting and design rather than abatement at the source, i.e. near-field quieting of the machinery itself. This is an entirely viable approach where a new site is developed. But there are far more cases where abatement efforts must be concentrated on the machinery in existing buildings.

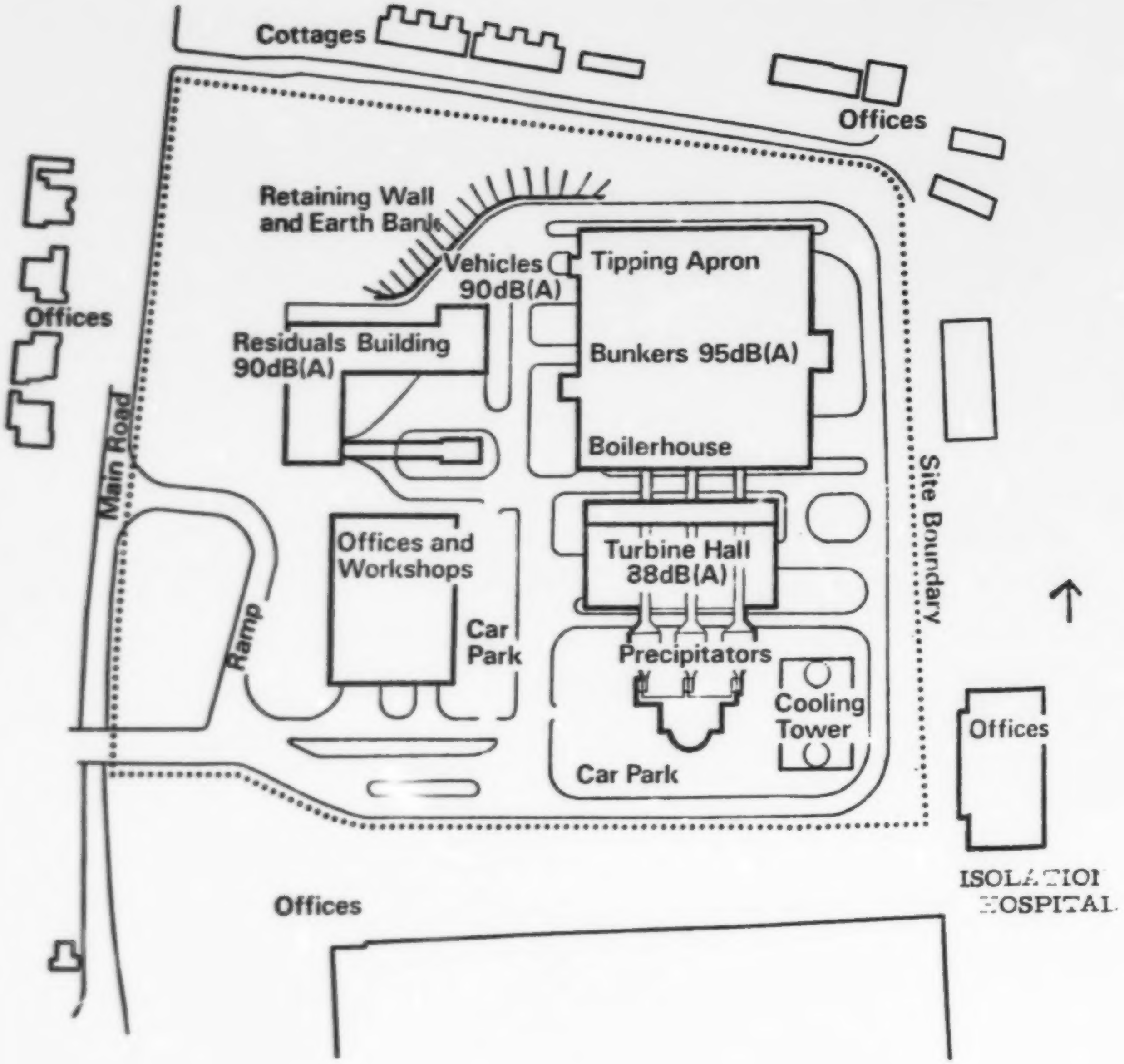
Cottages
Offices
Retaining Wall and Earth Bank
Vehicles 90dB(A)
Tipping Apron
Offices
Residuals Building 90dB(A)
Bunkers 95dB(A)
Main Road
Boilerhouse
Site Boundary
Offices and Workshops
Turbine Hall 88dB(A)
Car Park
Ramp
Precipitators
Cooling Tower
Offices
Car Park
ISOLATION HOSPITAL
Offices

Figure 7-1. Plan of a Refuse-Treatment Plant Designed in Accordance with Greater London Council Noise Abatement Guidelines.

Source: (7-23)

7.3 Noise from Construction Sites

7.3.1 Decision Criteria for Construction

Decision criteria for reducing construction noise varies according to the standard setting activities of individual nations. The British approach tests community reaction to construction noise. A test conducted by the University of Southampton's Institute of Sound and Vibration Research in North West London proved it necessary to gather data on exposure and reaction to noise from other sources as well. It was possible, however, to directly compare reaction in terms of annoyance and other attitudinal factors due to exposure to noise from the construction site, road traffic, and other sources (7-18).

The average reported annoyance for construction noise turned out to be significantly higher than that recorded for traffic noise (7-18).

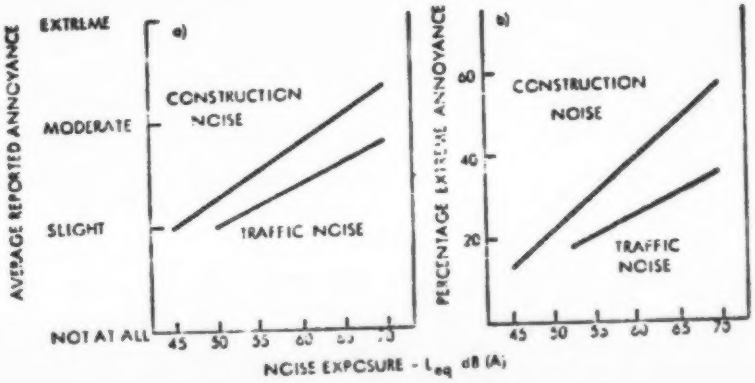

Fig. 7-2. Social Survey Annoyance Rating

Source: (7-18)

The University of Southampton's team suggests that:

> "The two most significant results of this study are the indications concerning the relative degrees of annoyance caused by given levels of construction and traffic noise and the apparent lack of dependence of annoyance on background noise level. It is instructive to examine construction noise according to some common methodologies for rating industrial or community noise such as ISO 1996, British Standard 4142 and the California Community Noise Equivalent Level methodology. In most cases construction noise exposure would be allowed to exceed a given criterion by 5 dBA because it is a temporary phenomenon. On the other hand, most construction noise is, at a given location, a novel stimulus and it frequently contains impulse noise. These factors together might result in a -10 dBA penalty being applied to construction noise. The resulting penalty of -5 dBA in terms of acceptability criteria would generally agree with the results shown in Figure 7-4. If nothing else it is possible to say that the construction noise appeared less acceptable than traffic noise" (7-18).

Teams of Danish scientists and technical specialists have been working since 1970 to develop comprehensive proposals for environmental protection. A sub-group formed May 28, 1970 to study construction noise had to resolve two controversial problems: the formation of the ideal construction noise regulation and the economic feasibility of strong regulation. Concerning the kind of regulation needed, they concluded from a survey of existing laws in neighboring European countries (Table 7-4) that one reason existing regulations were not being enforced was that many of the regulations were complex, with differentiated noise level limits and adjustment for duration of noise, tonal aspects of noise, etc. Therefore, the simplest regulation possible is the best regulation.

7.3.2 Direct Regulations

The Japanese Noise Control Law (Law No. 135, 1970) has approached the problem of decision criteria by limiting noise, working hours and days, as shown in Table 7-4. A unique feature is that while the regulation does not limit noise from certain equipment specifically, the zone limits depend on the type of equipment.

Automatic reductions in new product noise limits without further negotiation can greatly improve the effectiveness of the standards. An escape clause which covers a situation in which it proved to be technically impossible to meet a certain standard would provide the necessary flexibility to the "dynamic standards". This concept is an extension of the familiar principle of "lead time". An example of this approach is provided by the Federal Republic of Germany's regulations for noise from construction equipment. Another approach to improving the effectiveness of standards is foreseen in Switzerland where a dual system of standards is being devised for construction equipment. A special permit is required each time use is made of a machine emitting noise in excess of a lower ("relative") standard, while an upper ("absolute") standard provides a limit which may never be exceeded (7-20/14).

Besides direct regulations,some countries have developed codes of practice for noise control on construction and demolition sites. The British Standards Institution has produced a detailed code (BS 5228: 1975) which prescribes different measures and methods to control noise from construction. An acoustic shed design and performance characteristics contained in the mentioned code are presented in Figure 7-3 and Table 7-5.

Table 7-4 Limits of Noise of Working Hours and Days and Criteria for the Specified Construction Operation.

Specified construction operations / Items of criteria	Operations using pile drivers, pile extractors, etc.	Operations using riveters	Operations using rock drills	Operations using air compressors	Operations using concrete plants or asphalt plants installed
Noise level at a point 30m from the boundary of working site	85 dB(A)	80 dB(A)	75 dB(A)	75 dB(A)	75 dB(A)
Period during which noise is prohibited	7 pm – 7 am	7 pm – 7 am	9 pm – 6 am	9 pm – 6 am	9 pm – 6 pm
Period in a day within which noise is permitted	Not more than 10 hrs/day	Not more than 10 hrs/day	Not more than 10 hrs/day	Not more than 10 hrs/day	Not more than 10 hrs/day
Number of days noise is permitted	Not more than 6 consecutive days	Not more than 6 consecutive days	Not more than 6 consecutive days	Not more than 1 continuous month	Not more than 1 continuous month
Days during which noise is prohibited	Sundays and other holidays	Sundays and other holidays	Sundays and other holidays	Sundays and other holidays	Sundays and other holidays

Source: (7-19)

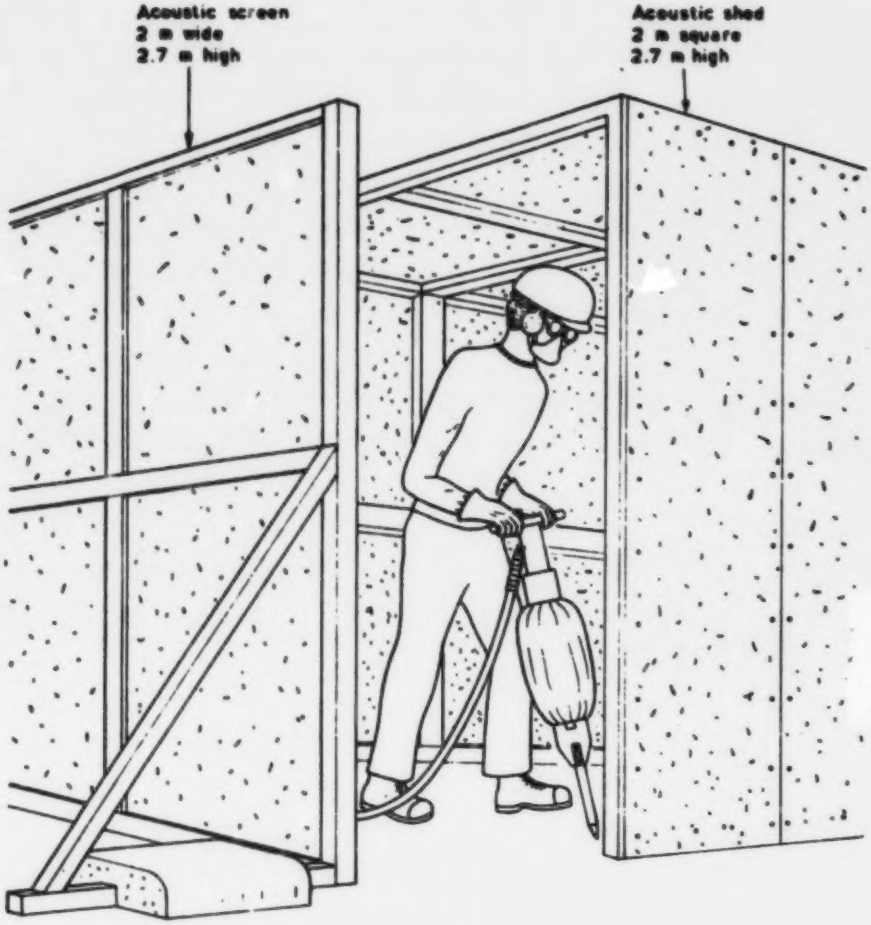
Acoustic screen
2 m wide
2.7 m high
Acoustic shed
2 m square
2.7 m high

Figure 7-3. Acoustic Shed Source 7-19

Type of enclosure (see figure 6)	Reduction		
	Facing the opening(s)	Sideways	Facing rear of shed
	dB(A)	dB(A)	dB(A)
Open-sided shed lined with absorbent: no screen	1	9	14
Open-sided shed lined with absorbent: with reflecting screen in front	10	6	8
Open-sided shed lined with absorbent: with absorbent screen in front	10	10	10

Table 7-5. Measured Sound Reduction Given by Types of Partial Enclosure Source (7-9)

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8. OCCUPATIONAL NOISE

8.1 Introduction

It is now widely realized that exposure to noise has a negative influence on the health of the exposed, in particular on persons exposed to high levels of noise on a regular basis, such as in occupational settings.

The working environment in which the workers spend a large part of their lives has a decisive influence on their health and safety, and also on their physical, mental and social well-being. The working environment is a complex set of interacting factors, of which noise is one, affecting individuals.

8.2 Direct Regulations

8.2.1 Overview

The national laws and regulations of some countries contain provisions that afford some degree of protection against the effects of noise which are dealt with in more detail in Chapter 10 of this report under the individual country sections. In addition, many codes of practice, guides, and recommendations have been published by various institutions in many countries either to illustrate the application of legislative provisions or to set up standards to prevent hazards not covered by the laws. A summary of known details is given in Table 8-1.

The scope of these tests and whether they are binding to the employers vary considerably. In some countries, mainly socialistic countries, standards are prepared by an official body and are obligatory. In other countries, (e.g. the United States)

	Existing 8-hour limit				Proposed limits					
	Law or Guideline	dBA	Max. dBA	Trading Ratio	For now	For later	By when	Audiometric testing mandatory?	Hearing loss compensable?	Ear protectors mandatory?
Australia	G	90	115	3 dB	90 dBA	85 dBA	5 years			
Austria	L (1974)	85		3				If > 85 dBA, each 3 yrs.		
Belgium		90	110	5						
Canada	L	90*	115	5						
Czechoslovakia		85		5	Yes				Yes	
Denmark	G (1974)	90		3						Yes
Finland	L (1974)	85*						If > 88 dBA, every 3 yrs. If > 100 dBA, every 1 yr.		
France	L (1975)	90		3						
E. Germany	L (1960)	85								Yes
W. Germany	L (1970)	90		3	85 dBA*		In effect May 1976		Yes	If L > 85 dBA
Netherlands	G	?			In prep.			Yes (details not known)		Yes (details not known)
Hungary										
Israel	G	?								
Italy	L (1956)	90	115	5						
Japan	G	90*								
Norway	None									
Poland										
S. Africa	L	85*		3						
Spain										Yes
Sweden	G	85		3						If L > 85 dBA*
Switzerland	G	90 ±2		3						
United Kingdom	G	90	135	3					Yes	
USSR	L	85*		3		80			Yes	If L ≥ 90 dBA
U.S.	L	90	115	5	90	85	5 years			
Yugoslavia	L (1971)	90		5					Yes	Yes

Table 8-1. Overview of Occupational Noise Laws•Source: (8-1)

Continuation of Table 8-1

	Measurements based on R 1999?	Source Emission Limits On Machines?	Impulsive noise limits?	**Notes** All assume 5 day, 40 hour week; 3 dBA trading ratio is the "Equal Energy Principle"
Australia	Yes			
Austria	Yes		Yes - add 10 dB to highest reading & calculate L_{eq}	
Belgium	Yes		100 (140-dBA peaks)/day	
Canada				• 85 dBA, e.g. in Alberta
Czechoslovakia	Yes			
Denmark	Yes		L_{eq} of [highest peak + 10 dBA]	
Finland	Yes			• New factories (since 1974) only
France	Yes			Warning signs in work areas ≥85 dBA
E. Germany	L_{eq} of [highest peak + 5 dBA]			
W. Germany				Workers with ear protectors get extra pay. • 90 for tough cases. Applies to new factories only.
Netherlands				
Hungary				
Israel				
Italy				
Japan				Law (1946) = 100 dBC limit.
Norway				
Poland				6-day week, 40-50 dBA in offices.
S. Africa			L_{eq} of [highest peak + 10 dBA]	• Only requirement is ear protectors over 85 dBA
Spain				• Available to workers
Sweden	Yes		140 dBA peak (guideline)	
Switzerland	Yes			
United Kingdom		(partial)		
USSR		Yes	Yes. Built into regular limits	50-65 dBA in various types of offices.
U.S.	Yes		Yes.	
Yugoslavia				6-day week

the regulations are based on or refer to standards laid out by specialized bodies, or by other organizations (e.g. in the Federal Republic of Germany). Some of the regulations refer to international standards (e.g. ISO) or to national standards of other countries which have been widely accepted (8-1 p 15)

Many countries have regulations on the compensation of occupationally induced hearing loss or deafness. There are also regulations and/or measures relating to medical, audiometric, and laboratory tests.

In most cases, the technical measures to be taken for dealing with noise are only mentioned in national laws and regulations and are of a general nature. They are confined to stating the principle that noise should be reduced as low as possible.

8.2.2 Notes On Countries

These notes clarify Table 8-1 and add more than space permits in Chapter 10.

Australia

This country submitted a draft hearing conservation regulation approved by the National Health and Medical Research Council of Australia. It is not known when this draft regulation will come into effect.

This draft regulation is partly based on an Australian standard (Standards Association of Australia Document 72084) and on the ISO Recommendation R 1999.

Legislation for 90 dBA/8 hours a day maximum noise exposure with the provision to reduce the maximum to 85 dBA/ 8 hours a day in five years time is proposed. This is considered to provide a time scale for the introduction of a desirable long-term standard. In addition, industry is supposed to make every effort to design machinery to meet this lower standard and that new premises should be designed to meet this standard. The proposed legislation also contains recommendations that attempts should be made to monitor achievements in these regards in order to aid legislation in determining further long-term policies toward a more ideal situation.

Austria

Occupational noise exposure is regulated within the Occupational Law: Z:61.021/10-6/1974, March 13, 1974. This law regulates the use of workers for certain types of jobs. The workers' health has to be examined to determine their physical suitability for, e.g., jobs with high noise level. If their health allows them to work in such jobs further periodic health examinations have to be conducted, e.g., audiometric testing every three years.

The Guideline No. 3 (part 2) of the Austrian Working Group for Noise Abatement serves as a basis for the determination of dangerous noise levels at places of work. Noise levels over 85 dBA are considered dangerous regarding damage to hearing.

The law does not give a definition of the term "excessive noise level" but only says that workers have to be tested audiometrically if the noise level at their job exceeds 85 dBA. The employer also has to supply the workers with "proper" hearing protection and instruct them as to their use.

The employees have the duty to undergo the health examination and to contribute to the protection of their hearing. Theoretically, therefore, a worker's hearing is tested before he would start on a job having "excessively noisy" (over 85 dBA) conditions. If his hearing is "normal", he would be allowed to work on that particular job for three years. If some change in his audiometer test would show up after that time, he would not be permitted to continue the job. However, the workers' physician could order an examination at any time during the three-year period if deemed necessary. Also, the safety inspectors (employed by the Austrian Department of Labor) can order examinations at any time if it seems warranted.

Belgium

This country had an occupational safety regulation including provisions to protect workers against the effects of noise since 1972. Maximum permitted noise levels are set at 90 dBA.

Canada

There is a Federal Noise Control Regulation which limits the noise exposure of employees to 90 dBA/8 hours with an overriding limit of 115 dBA. In addition, state laws are in effect, which also regulate noise exposure of workers. All states allow noise exposure of workers up to 90 dBA, with the exception of Alberta, where the maximum is set at 85 dBA/8 hours. Alberta also sets the impulse peak at 140 dBA.

The Federal law permits exposure to 90 dBA or more where hearing protection reduces the level to less than 90 dBA or where a test establishes no hearing impairment for employees exposed to 90 to 95 dBA, and regular tests are conducted.

Warning signs are mandatory at entrances to work sites where there are dangerous sound levels. Hearing loss from industrial noise is generally recognized in Canada and is usually compensable relative to the degree of impairment.

Czechoslovakia

The regulations in force at this time (promulgated in 1967) give detailed instructions to the producer of machines and to the employer on how to attempt to meet the maximum permissible noise limit.

In case these conditions cannot be met due to technical reasons, the workers have to be supplied with and have to wear hearing protectors with adequate attenuation. If workers have to wear hearing protectors at all times during their shift, breaks have to be allowed at regular intervals (not specified) in a quiet environment. Further measures can be ordered by the government working inspection. Only workers deemed physically suitable for work in a noisy environment by a medical examination may be used.

A new regulation for the protection of workers against the effects of noise will be promulgated in 1976. No mention was made as to possible changes the new regulation may bring.

Denmark

The Danish regulation is based on the criteria put forward in ISO R 1999, and the Danish Ministry of Labor Publication No. 38, 1972 "Noise in the Workplace." The latter gives basic information about noise measurement methods, how to reduce noise in factories, and audiometric testing of workers.

Finland

The Finnish regulation sets a limit of 85 dBA for places of work. In addition, manufacturers, importers, installers of equipment, and dealers are held responsible for the purchase and proper installation of new equipment to fulfill the 85 dBA noise emission limit. New and existing machines with higher noise emission and equipment generating vibrations have to be put in separate facilities and be fully enclosed. In cases where the noise level cannot be reduced to 85 dBA for technical reasons, personnel has to be supplied with effective and officially approved ear protectors.

Warning signs have to be posted to designate areas where the noise level exceeds 85 dBA. In cases of fluctuating noise, warning devices have to be installed to indicate whenever 85 dBA is exceeded.

This regulation came into effect on October 1, 1974 and is valid for all facilities coming into operation since then. The authorities will determine transition periods for existing facilities so that the necessary changes can be executed smoothly.

France

From a secondary source, it is understood that France has had a regulation since 1970. (8-3)

The standard AFNOR S31-013 of 1969 uses the ISO R 1999 method for the calculation of the equivalent continuous noise level using partial noise exposure indices and for the estimation of the risk of hearing impairment.

German Federal Republic

On December 1, 1974, the regulation "Accident Prevention Noise" came into force.

The subject of this regulation is the prevention of hearing loss or damage and of accidents partly or solely due to noise. Non-auditory effects of noise are not regulated at this time.

Noise emissions over 85 dBA are considered dangerous to hearing which takes into consideration (verbatim) "that the risk of hearing damage due to long-term exposure to noise in case of sensitive persons commences at 85 dBA, particularly if the noise is high frequency or impulsive. Otologists are of the opinion that the danger limit has to be set as low as 80 dBA."

The use of personal hearing protection is only considered if it has been proven that no other means could help to reduce the noise level to 85-90 dBA. The employer has the duty to designate so-called "noise areas" in the plant and employees have to be offered the opportunity to use hearing protection in areas of levels below 85 dBA if they so desire. It is the legal duty of the employees to wear hearing protectors in designated "noise areas", regardless of how long they remain in these areas.

Another important aspect of this regulation is the matter of the prevention of accidents directly attributable to noise. The conclusion derived from the review of work accident reports was that in many cases accidents happened owing to unsafe behavior, erroneous or slow reactions, or human failure directly attributable to noise. To give examples: masking of warning signals by noise, startle reactions due to sudden impulses or bursts of noise.

Part 5 of the law gives methods for the prevention of these types of accidents. However, experience has to be gained since this area is a fairly novel one.

Extensive provisions are also given for audiometric testing: 1) to determine the suitability of a person for a job under noisy conditions; 2) to test the hearing of workers after one year on a noisy job; and 3) repeat audiometric tests every three years thereafter. The employer has to arrange for these examinations and bear the costs. Results have to be filed by the employer in a so-called health file, which also contains any other information and workers' anamnestic data.

An extensive description of the law outlined above is given in a series of articles published in the journal Arbeitsschutz 1:(1975). Discussions of the quality of the law and its impacts are given.

Another law is in draft stage: "Work Place Ordinance, draft 084174". It is proposed in this draft that the noise level in places of work should be kept as low as technically feasible and should also depend on the nature of the work performed, e.g., for intellectual work 55 dBA, simple office work 70 dBA, and 85 dBA for all other kinds of work if technically feasible; if not, this level may be exceeded by 5 dBA.

Netherlands

The only existing regulation is "The Industrial Safety Act" (July 1934 - Bulletin of Acts, Orders, and Decrees, 352). It gives rules for industrial safety and health. The Act (Sections 7, 9, 11, and 20a) gives powers to draw up rules relating to the prevention or restriction of harmful and annoying noise and to the time during which workers are allowed to remain in a location with harmful noise.

Provisions to support these rules are in preparation for various individual sectors.

In the "Industrial Safety Decree" for factories and workshops, there is a regulation concerning the wearing of earplugs (no description obtained).

Under the "Dangerous Instruments Act", it is possible to set noise emission standards for certain categories of machines in the interest of the health of the users.

References

8-1 Meyer, Ingrid. Occupational noise exposure, the standards and regulations in major industrial countries; draft. Rockville, Informatics, June 10, 1975.

8-2 South African Bureau of Standards. Code of practice for the assessment of noise - exposure during work for hearing conservation purposes. SABS 083-1970. Pretoria, South Africa. 15 p.

8-3 Hay, B. International legislation on external industrial noise. Applied Acoustics, 8:133-140, 1975.

8-4 Canada Department of Labour. 1973 industrial noise; legislation concerning industrial noise in Canada. April 1974. 30 p.

8-5 Australian Department of Labour and Industry. Industrialized safety code regulations under the industrial safety, health and welfare act, 1972; regulation 49, noise levels and protection from noise. Government Gazette, June 26, 1975.

9. INFORMATION CENTERS ON NOISE

The object of this short section is to identify some of the organizations that are systematically gathering and processing reports and documents on noise pollution and its abatement and control (Table 9-1). These organizations in general do not exist only to serve the general public, but often may provide outside users some king of access on a case by case basis. Forms which such access might take include: receiving periodic publications, use in person of a library facility, computer literature searches, limited document services, referral to other sources of documents or information, etc.

For Japan, the reader is referred to a tabulation of Japanese information sources in Section 16 of Chapter 10 (Vol. II, p. 10-151).

For information on noise measurement standards, the reader is referred the information on ISO in Chapter 2.

It is to be hoped that as time passes, one or more information centers may develop more extensive and publicized programs for supplying documentation and other forms of information to the general public.

TABLE 9-1. INFORMATION CENTERS ON NOISE

Name	Place	Description	User Terms	Contact for Use
Noise Information Program, U.S. EPA	Washington, D.C.	Largest info center in the world dedicated solely noise documentation. 1) 20,000+ documents. 2) 6,000+ abstracts in the "CIS" on-line computerized information retrieval system. 3) Publishes numerous directories, etc. 4) Literature search services.	By permission of U.S. EPA,	**Dr. Kurt Askin Office of Noise Abatement & Control U.S. EPA Washington, D.C. 20460**
UMPLIS	Berlin, W. Germany	Umbrella environmental info system sponsored by W. German Environmental Ministry (Umweltant), formerly by Ministry of the Interior (Bundesministerium des Innen).	Public users terms not known.	Dr. Wolfgang Kitschler Dept. of the Interior Rheindorferstrasse 198 53 Bonn, W. Germany
Centre de Formation et de Documentation sur les nuisance (CFDN)	Paris	Center for industrial environmental information (occupational health, occupational noise). Answers queries by telephone or mail.	Available to public as well as official users.	11 bis, rue Leon Jouhaux Paris 10^{e} France Attn: R. Ridre, Information Specialist.

Name	Place	Description	User Terms	Contact for Use
ISVR	Institute of Sound & Vibration, Southampton, England	Noise document library. Vibration abstracts collection.	Public user terms not known.	Ms. Mavis Bull, Librarian ISVR University of Southampton England.
Bibliographic Reference System on Noise Control	Ottawa, Canada	Data base consists of bibliographic references to noise documents, stored in computer and with batch-mode retrieval.	Available to public.	Dr. Robert Tackl Noise Control Environment Environmental Protection Service Environment Canada Ottawa, Canada
VDI Documentation-stelle	Society of German Engineers	1) Noise document library. 2) Monthly bibliography in German, from worldwide sources.	Public user terms not known.	Herr Karl Neumann Verein Deutscher Inginieure 4 Dusseldorf 1 Postfach 1139 West Germany

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